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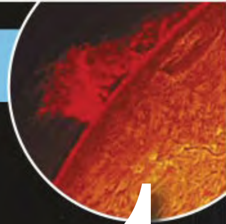

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Sky at Night

PLUTO

A NEW CHAPTER

New Horizons at the edge of the Solar System

PLUS The discovery and demotion of a planet

INTERVIEW: CHRIS HADFIELD

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Welcome

It's been a long time coming, but we've finally reached Pluto

This month's contributors include...

PAUL ABEL
PRO ASTRONOMER

Paul unravels the twisting tale of Pluto, from orbital anomaly to gatekeeper of the Kuiper Belt. *Page 63*

PETE LAWRENCE
IMAGING EXPERT

Pete reviews the Software Bisque Paramount MYT, a mount that combines superb precision with unexpected portability. *Page 90*

CHRIS LINTOTT
SKY AT NIGHT PRESENTER

Chris explains why looking at the heart the Milky Way could help us work out the finer points of star formation. *Page 14*

ELIZABETH PEARSON
NEWS EDITOR

Elizabeth brings us the details of the New Horzions flyby – from the science goals to when we can expect images. *Page 69*

After a nine and a half year voyage, New Horizons will streak into history on 14 July by making the first close flyby of the Pluto system. It's a moment that will be over in a matter of hours, and a manoeuvre that represents an enthralling payoff. Mission planners opted for record speed to cover the vast distance to Pluto (on average 40 times further from the Sun than Earth is) and get there on a realistic timescale, rather than carry the extra weight of the fuel needed to slow it into an orbit. And, as Elizabeth Pearson explains on page 69, the mission's sensitive instrument suite will not be wasting a moment, collecting data for weeks either side of the closest approach.

The day of New Horizons' flyby is the latest chapter in Pluto's fascinating history. It has always had a certain appeal – and is perhaps the only body in the Solar System to have had a Disney cartoon character named after it. On page 63 Paul Abel tells this story, a tale that starts in the mid-19th Century, takes in discovery in 1930 and then declassification in 2006.

There is nothing so contentious about the Sun, and Will Gater is your guide to observing and imaging it safely on page 32. There is rich detail visible on our star in hydrogen-alpha light, and it can be revealed and captured using the methods and equipment he describes. We also feature stunning images of another target on page 39: planet Earth as seen from the International Space Station. And we spoke exclusively to astronaut Chris Hadfield about the impact that an orbital vantage point has on the space station crew.

Enjoy the issue!

Chris Bramley Editor

PS Next issue goes on sale 20 August.

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Editorial enquiries
BBC Sky at Night Magazine, Immediate Media Co Bristol Ltd, Tower House, Fairfax Street, Bristol, BS1 3BN

In the magazine

NEW TO ASTRONOMY?
See *The Guide* on page 80 and our online glossary at www.skyatnightmagazine.com/dictionary


THE LAST NEW HORIZON 69

REGULARS

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(C) = on the cover


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BBC Sky at Night MAGAZINE

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EDITORIAL
Editor Chris Bramley
Art Editor Steve Marsh
Production Editor Kev Lochun
News Editor Elizabeth Pearson
Editorial Assistant Iain Todd
Reviews Editor Paul Money

CONTRIBUTORS
Paul Abel, Maggie Aderin-Pocock, Mark Bowyer, Adam Crute, Jon Culshaw, Lewis Dartnell, Glenn Dawes, Mark Garlick, Will Gater, Brian Jones, Pete Lawrence, Chris Lintott, Sa'id Mosteshar, Hazel Muir, Gary Palmer, Steve Richards, Steve Sayers, Paul Sutherland, Stephen Tonkin, Emily Winterburn, Paul Wootton

ADVERTISING SALES
Advertising Managers Steve Grigg (0117 314 8365), Tony Robinson (0117 314 8811)
Inserts Laurence Robertson (00 353 87 690 2208)

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Production Coordinator Stephanie Smith
Ad Services Manager Paul Thornton
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Ad Designers Cee Pike, Andrew Hobson
Reprographics Tony Hunt, Chris Sutch

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International Partners' Manager Anna Brown

MARKETING
Head of Circulation Rob Brock
Head of Marketing Jacky Perales-Morris
Marketing Executive Ethan Parry
Head of Press and PR Carolyn Wray (0117 314 8812)

PUBLISHING
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Managing Director Andy Marshall

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SUBSCRIPTION RATES
Annual subscription rates (inc P&P): UK cheque/credit card £59.88; Europe & Eire Airmail £69; rest of world airmail £79. To order, call 0844 844 0260

ISSN 1745-9869

Cosmic champagne flow

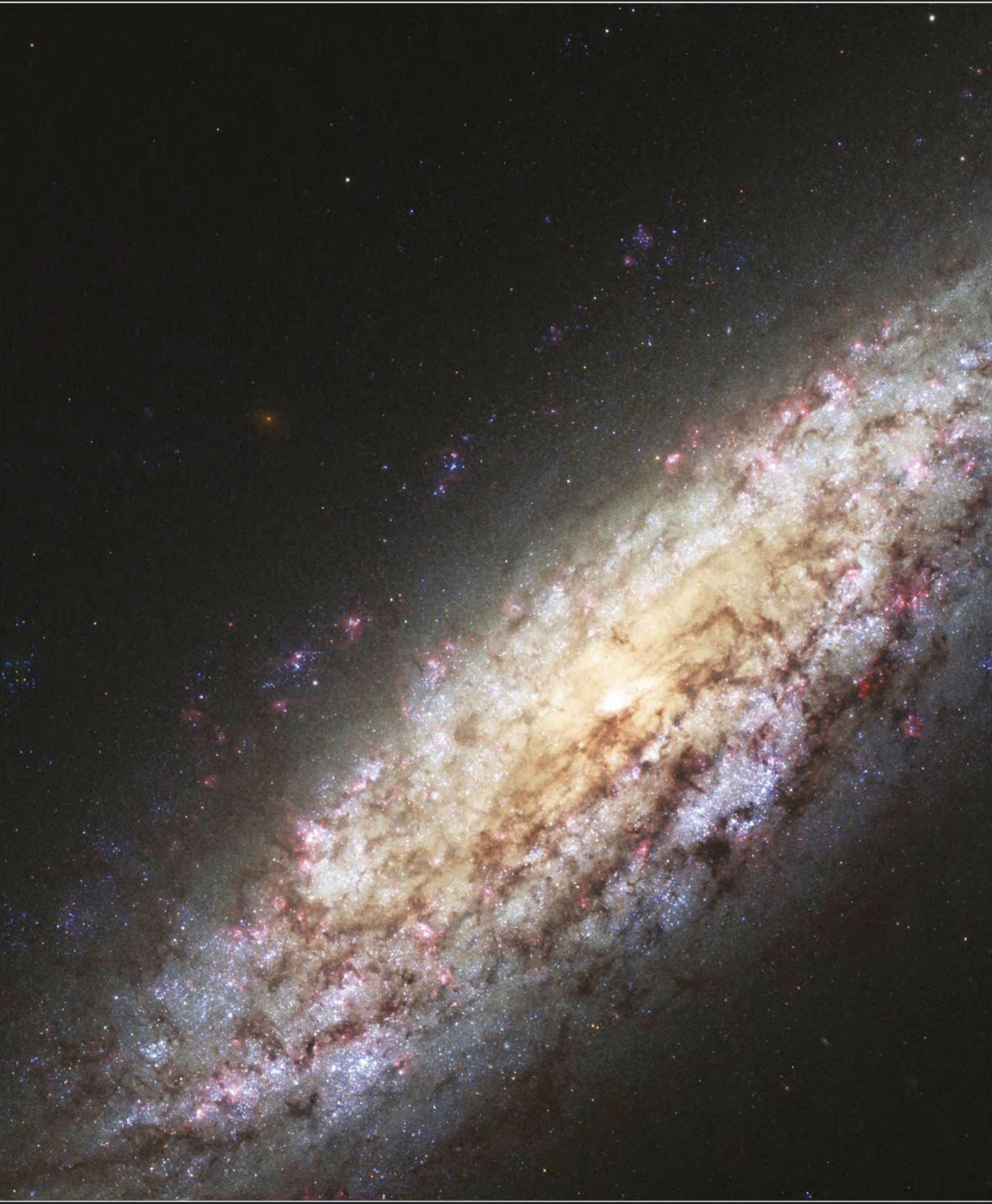
VERY LARGE TELESCOPE, 27 MAY 2015

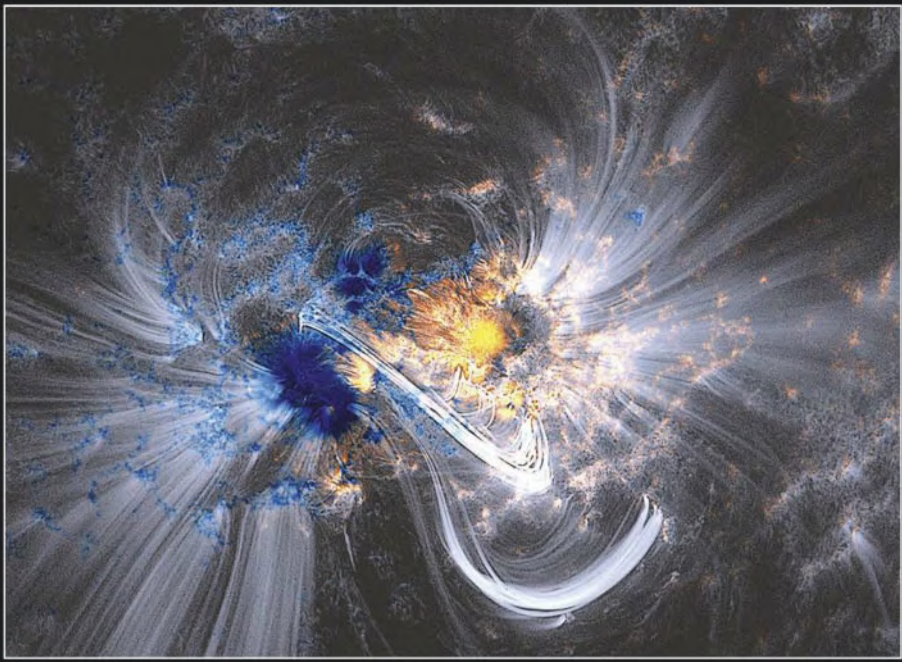
Dust and gas hide the inner workings of a vibrant stellar nursery from view

RCW 34 is a brightly coloured star-forming cloud of gas in the southern constellation of Vela. This image shows a red cloud of hydrogen that is being heated and is expanding through the surrounding cooler gas. When the hydrogen reaches the limits of the cloud, it bursts into the vacuum in the same manner as a bottle of champagne that has been shaken until its cork pops off. The process, perhaps unsurprisingly, is referred to as ‘champagne flow’.

Vast amounts of dust mask the many young stars forming inside the RCW 34 nebula. As a result, this stellar nursery has a high extinction, meaning its visible light is absorbed before it can reach Earth. But infrared telescopes can be used to peer through the dust, revealing young stars clumping around their older counterparts in the centre. This irregular distribution has led to the suggestion that RCW 34 has seen three distinct periods of star formation during its life.

ESO

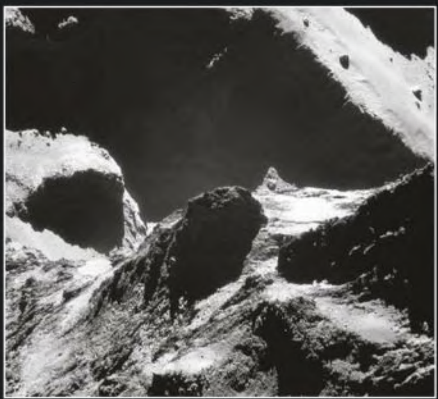




▲ Solar magnetism

SOLAR DYNAMICS OBSERVATORY, 22 MAY 2015

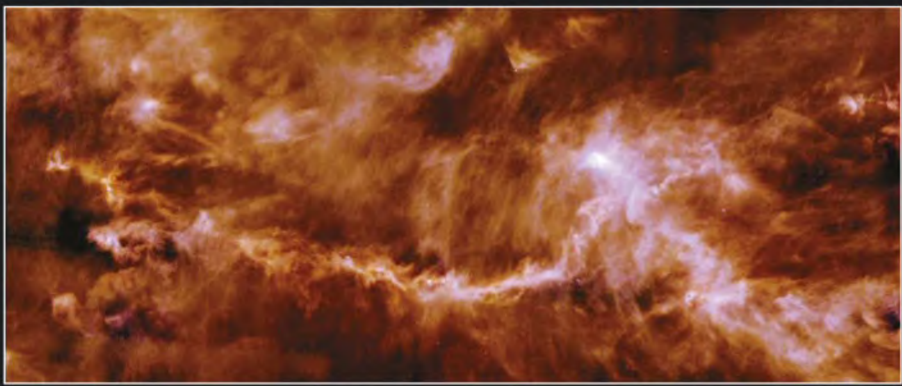
This chaotic image is from the Atmospheric Imaging Assembly (AIA) on NASA's Solar Dynamics Observatory. When the AIA's images are sharpened, the magnetic field can be seen through bright strands called coronal loops. The loops are shown in this image in an overlay with the magnetic field; blue and yellow indicate opposing polarities.



◀ Comet close-up

ROSETTA SPACECRAFT, 28 MAY 2015

This recently released shot from the Rosetta spacecraft, captured on 19 October 2014, looks across the neck that joins the small lobe of comet 67P/Churyumov-Gerasimenko in the foreground to the large lobe behind it. The shot was taken 9.9km from the comet's centre and about 7.9km from the surface.



▲ Future star formation

HERSCHEL SPACE OBSERVATORY, 8 JUNE 2015

While it may look like a fireball of destruction, the Taurus Molecular Cloud is in fact a massive stellar nursery. The image shows a jumble of interstellar filaments which, it is thought, will eventually form stars as the effect of gravity causes them to contract and fragment.

NASA/ESA, NASA/SDO, ESA/ROSETTA/NAVCAM, ESA/HERSCHEL/PACS/SPIRE/GOULD BELT SURVEY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Bulletin

The latest astronomy and space news written by **Hazel Muir**

PLUS CUTTING EDGE

Our experts examine the hottest new astronomy research papers

ESA's sleeping beauty awakes

The comet lander Philae has finally phoned home

ROSETTA'S PHILAE LANDER has awoken on the surface of Comet 67P/Churyumov-Gerasimenko after a long hibernation. ESA mission controllers were thrilled to receive signals from the lander in mid-June, when the comet moved close enough to the Sun to charge up the lander's solar-powered batteries.

The Rosetta spacecraft, which is currently orbiting the 4km-wide comet, dropped Philae onto the dusty snowball's surface in November last year. But the lander communicated for only 60 hours because it fell into a shadowy ditch, where its solar panels received very little sunlight.

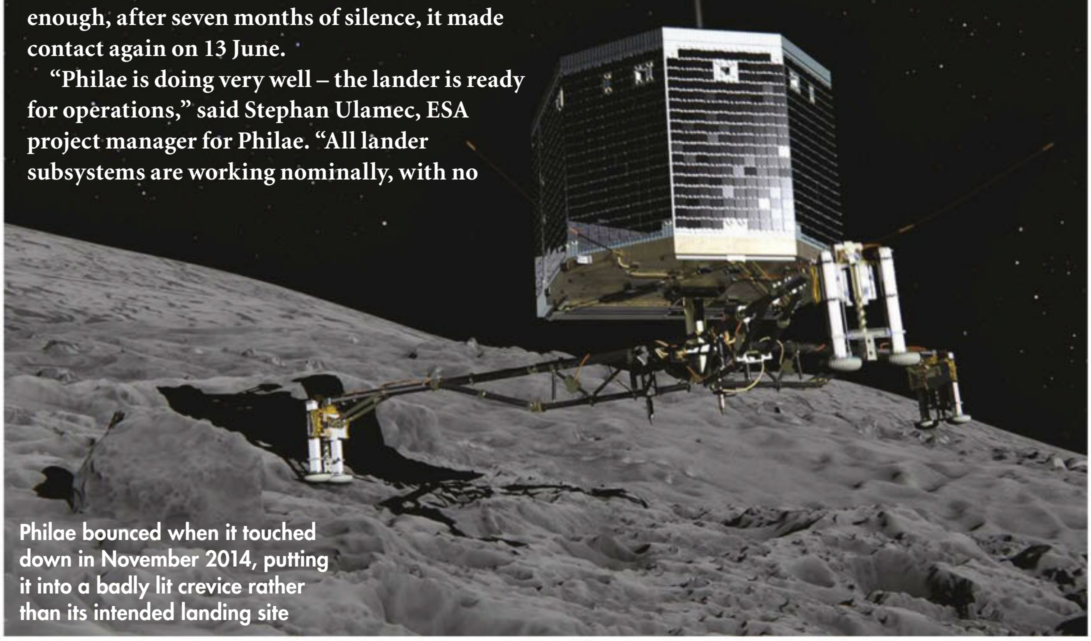
Scientists hoped the lander would 'reawaken' as the comet moved closer to the Sun. And sure enough, after seven months of silence, it made contact again on 13 June.

"Philae is doing very well – the lander is ready for operations," said Stephan Ulamec, ESA project manager for Philae. "All lander subsystems are working nominally, with no apparent degradation after more than half a year hiding out on the comet's frozen surface."

Since then, the first priority has been to assess the lander's position and orientation, then measure environmental features such as temperatures and magnetic fields. If Philae's batteries continue to power up, it will hopefully beam back sharp images of the weird cometary landscape and eventually drill into the surface to analyse its chemical composition.

The mission remains precarious for both Rosetta and Philae, however, because the comet will continue to heat and activate, fizzing out gas and dust unpredictably. It will make its closest approach to the Sun on 13 August.

▸ **See Comment, right**



Philae bounced when it touched down in November 2014, putting it into a badly lit crevice rather than its intended landing site

ESA/ATG MEDIALAB

COMMENT

by Chris Lintott

As we scrambled to make last-minute edits to our Rosetta episode of *The Sky at Night* once Philae woke up, we couldn't give many details about what state the plucky lander was in, but the news is fantastic. The late wake-up, due to temperatures that were lower than many expected, means the chances of Philae surviving perihelion are excellent. Protected by the 'cave' in which it finds itself, it should be sheltered from the heat of the Sun.

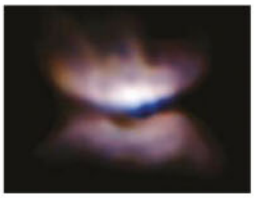
Getting Rosetta in the right place to communicate with the lander is likely to be the bigger problem for the team. It's already struggling to navigate around the active comet, with the star tracker it relies on for positioning confused by glittering comet dust. This voyage has always been about precision flying, from the initial rendezvous with the comet to Philae's descent, and now once more the skills of the mission control team will be tested.

CHRIS LINTOTT co-presents *The Sky at Night*

NEWS IN BRIEF

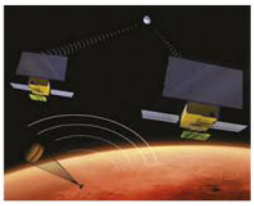
CELESTIAL BUTTERFLY TAKES SHAPE

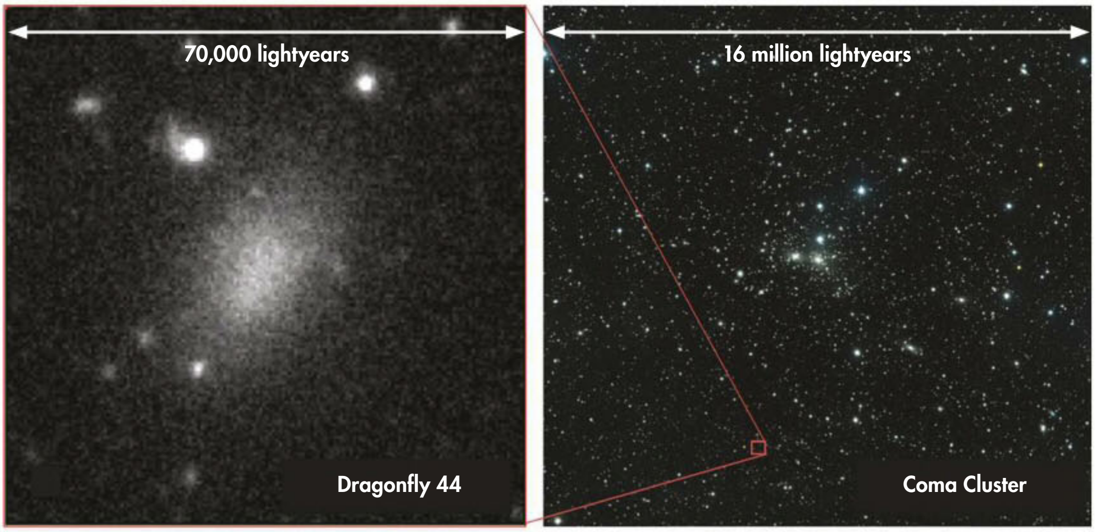
Astronomers have witnessed an ageing star giving birth to a butterfly-like planetary nebula. A dusty disc surrounds the star, L2 Puppis, which lies 200 lightyears away, and it's blowing out two distinct lobes of material sculpted by the gravity of a companion star orbiting every few years. "It will be possible to follow the evolution of the dust features around the star in real time – an extremely rare and exciting prospect," says team leader Pierre Kervella from the University of Chile in Santiago.



MINI PROBES HEAD FOR MARS

Two CubeSats – small spacecraft just 10cm across – will accompany NASA's InSight mission to Mars. The CubeSats should launch in March 2016 on the same rocket as the InSight lander, but will follow independent trajectories to the Red Planet. The CubeSats will beam back information about InSight's fate during the crucial few minutes between entering the Martian atmosphere and touchdown.





▲ Dragonfly 44, left, is one of more than 800 ultra-diffuse galaxies found to exist within the Coma Cluster, right

Fluffy galaxies are a class of their own

Some enormous galaxies are surprisingly wispy and dark

HUNDREDS OF NEWLY discovered 'fluffy' galaxies are baffling astronomers. The so-called ultra-diffuse galaxies are often as wide as our own Milky Way yet they contain less than one per cent as many stars. "If the Milky Way is a sea of stars, then these newly discovered galaxies are like wisps of clouds," says Pieter van Dokkum from Yale University in Connecticut. "It's remarkable they have survived at all."

Using a small 10-lens telescope called the Dragonfly Telephoto Array in New Mexico, van Dokkum's team identified more than 40 faint fuzzy objects that turned out to reside in a congregation of galaxies called the Coma Cluster (Abell 1656), which lies roughly 320 million lightyears away. That means they are very large and distant dim galaxies, rather than small objects fairly close to us.

Since then, analysis of archived data from the Japanese Subaru Telescope in Hawaii has revealed that these ultra-diffuse galaxies are far from rare – the Coma Cluster contains more than 800 of them. Jin Koda from Stony Brook University in New York and colleagues showed that many are similar in size to the Milky Way but with only 1/1,000th of the stars.

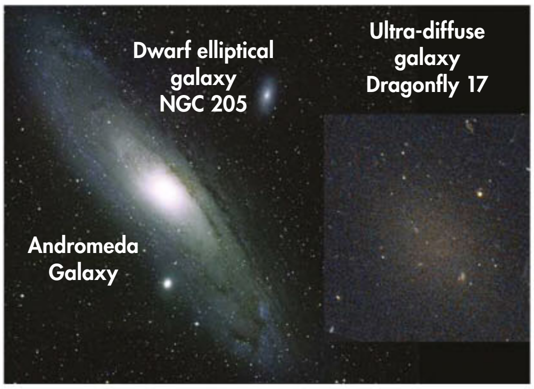
"If there are any aliens living on a planet in an ultra-diffuse galaxy, they would have no band of light across the sky, like our own Milky Way," says van Dokkum's colleague Aaron Romanowsky from San Jose State University in California.

How the wispy galaxies can exist is unclear. They inhabit a dense, violent region of space filled with galaxies whizzing around and could easily be disrupted by external gravitational forces.

Possibly, they're glued together by the gravity of extreme amounts of dark matter, the unidentified invisible substance that makes up most of the mass in the Universe. "They must be cloaked in their own invisible dark matter shields that are protecting them from this intergalactic assault," says van Dokkum.

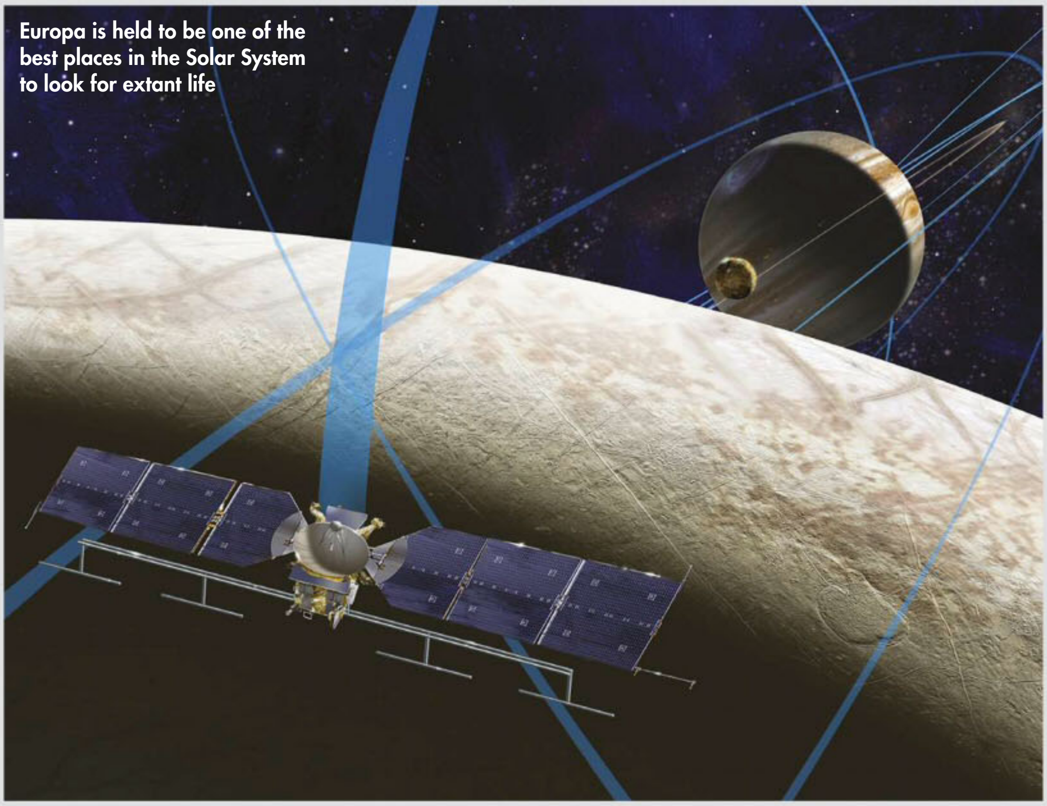
The fluffy galaxies may turn out to be 'failed' galaxies that ran out of star-forming gas. Alternatively, they could be normal galaxies that have been gravitationally disturbed so often inside the Coma Cluster that they puffed up.

http://subarutelescope.org



▲ Ultra-diffuse galaxy Dragonfly 17 shown to scale alongside the Andromeda Galaxy and NGC 205

ESO/P. KERVELLA, NASA/JPL-CALTECH, P. VAN DOKKUM/R. ABRAHAM/J. BRODIE, B. SCHOENING, V. HARVEY/REU PROGRAM/NOAO/AURA/ NSF, P. VAN DOKKUM/HUBBLE SPACE TELESCOPE, NASA/JPL-CALTECH, ESA/HUBBLE/L. CALCADA (ESO), ESO, ESO/M. KORNMESSER



Europa is held to be one of the best places in the Solar System to look for extant life

NASA gears up for Europa mission

Nine state-of-the-art instruments will probe the mysterious moon

NASA HAS SELECTED nine science instruments for a mission to study Jupiter's moon Europa. The unnamed mission would launch in the 2020s and investigate whether the moon could harbour life. There's strong evidence that Europa has a warm salty ocean beneath its frozen crust – possibly a habitable environment for microbes. The ocean is also believed to be in contact with a rocky sea floor and subject to tidal heating.

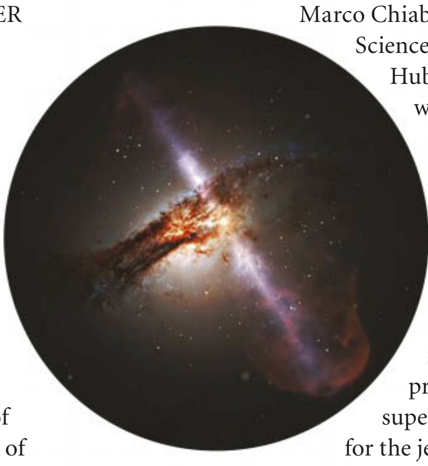
The mission would see a spacecraft orbit Jupiter and perform close flybys of Europa over three years. Its instruments would image the surface and determine its composition, and measure the thickness of the moon's icy shell. They would also gauge the depth and salinity of Europa's ocean and investigate plumes of particles sprouting out from its surface.
www.nasa.gov/europa

GALAXY MERGERS WAKEN BLACK HOLE JETS

GALAXIES MERGING TRIGGER the production of energetic jets from supermassive black holes, astronomers have proved unambiguously for the first time. The spin rate of the black hole may also be an important factor.

Many energetic galaxies shine extremely brightly as material swirls towards a supermassive black hole at their centres, heating to extreme temperatures. A small fraction of these black holes also sprout jets of energetic particles into space at almost the speed of light. To investigate the jets, a team led by Marco Chiaberge from the Space Telescope Science Institute in Maryland used the Hubble Space Telescope to study a wide range of galaxies, some with jets and some without. Almost all galaxies with jets showed evidence of having merged with another in the past.

However, not all merged galaxies create jets. "It could be that a particular breed of merger between two black holes produces a single spinning supermassive black hole, accounting for the jet production," says team member Colin Norman from Johns Hopkins University.
www.hubblesite.org



▲ The energetic jets – outflows of plasma – have amazingly strong emissions at radio wavelengths

NEWS IN BRIEF

MEDUSA'S GLORIOUS GLOW REVEALED

The Very Large Telescope in Chile has captured the most detailed image yet of the Medusa Nebula, which lies 1,500 lightyears away in the constellation of Gemini. The central star has shed its outer layers into space, forming a colourful cloud – a planetary nebula. This phase of stellar evolution is fleeting, lasting only a few tens of thousands of years before the star shrinks into a white dwarf.

MONSTER STARS FROM THE DAWN OF TIME

Astronomers have spotted a bright galaxy dating back to the early Universe that may harbour some of the first generation of stars that ever formed – extremely massive stars that manufactured the first heavy elements in history through nuclear reactions. "They formed the first heavy atoms that ultimately allowed us to be here," says team leader David Sobral from the University of Lisbon, Portugal. "It doesn't really get any more exciting than this."

CUTTING EDGE

Our experts examine the hottest new research

The secrets of stars

The key to understanding how stars first form in galaxies may lie in the heart of our own

▲ The model accounts for why some barred spiral galaxies show intense star formation but others are quieter

ESO/P. GROSBØL

The centres of spiral galaxies are funny places. Never mind the supermassive black hole lurking at the centre, the flow of gas into and around the centre of the galaxy can have dramatic effects. This is particularly true in systems like the Milky Way, which have a long bar crossing the centre, and a recent paper by Mark Krumholz of the University of California Santa Cruz and Diederik Kruijssen of the Max Planck Institute for Astrophysics in Germany uses these unusual places to peer into the mysteries of how stars form.

I've always found it curious that star formation is mysterious. It seems odd that though we can describe the basic process easily – a clump of cold gas collapses under its own gravity until the point where nuclear reactions can start – the details are obscure. We don't know what triggers star formation, we don't know what controls the mass of a star and we don't know how it is affected by the galaxy. It's this latter question that this study addresses, attempting to distinguish between the sensible argument that a single forming star doesn't know much about its surroundings and the equally plausible argument that the properties of the clouds from which stars form varies depending on the environment.

CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project.

If surroundings do make a difference to stellar nurseries, then a galaxy's centre is the place to look. It's the place where things are most confused; in the Milky Way, gas in believed to be transported along the bar to the centre where it piles up. This sounds like it should favour star formation – the piling up of gas should increase the density overall, after all – but the computer simulations carried out by the team suggest things are complicated.

As the gas rushes inwards along the bar, it is much less likely to form stars. Its rapid movement actually prevents star formation, and it's not until it accumulates closer to the centre that star formation can really get going. Even then, things are complicated. Stars can form as such a rate that what the authors describe as a 'blowout' occurs, with gas being expelled from the centre and star formation being placed on hold until sufficient fuel can once again accumulate.

This is a complex story, and given that it depends both on broad assumptions about what physics is important and on some nifty simulations, I'd be skeptical about it were it not for the pile-up of evidence presented. Most impressive is the fact that the authors see in their computerised galaxy the

> "It seems odd that we can describe the basics of star formation, but the details are obscure"

formation of a ring of gas a little more than 300 lightyears from the centre. Just such a ring is observed in the Milky Way, and if this work is right something like it should appear in every barred galaxy.

Even better, the model explains why we see all sorts of behaviour in the centre of nearby barred galaxies. Some are hives of activity, while others are quiet, behaviour that is a natural consequence of a model that switches star formation on and off. Further observations will help, and the authors end with an unusual plea – ALMA, up high in the Atacama Desert, could peer into the hearts of many nearby galaxies, but has not yet. They think it should, and I agree. The secrets of star formation are there for the taking.

CHRIS LINTOTT was reading… *A Dynamical Model for the Formation of Gas Rings and Episodic Starbursts Near Galactic Centres* by Mark R Krumholz and J M Diederik Kruijssen
Read it online at http://arxiv.org/abs/1505.07111

Warm Neptunes galore

Gassy planets cloaked in helium could be commonplace

▲ Astronomers have detected a huge cloud of hydrogen being stripped from Neptune-sized Gliese 436b

MANY PLANETS IN the Milky Way could be shrouded in helium. Observations by NASA's Spitzer Space Telescope, combined with theoretical arguments, suggest that warm Neptune-sized planets with clouds of helium may be strewn around our Galaxy by the thousands.

Renyu Hu from NASA's Jet Propulsion Laboratory in California and colleagues say that much of the dominant hydrogen in Neptune-sized planets that orbit close to their parent stars has been 'slow-cooked' off by intense stellar radiation, leaving them helium-rich. "Hydrogen is four times lighter than helium, so it would slowly disappear from the planets' atmospheres, causing them to become more concentrated with helium over time," says Hu.

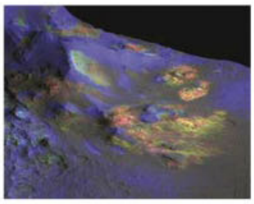
www.nasa.gov/spitzer

NEWS IN BRIEF

DOES MARTIAN GLASS HOLD SECRET TO LIFE?

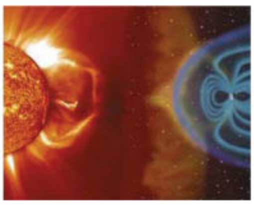
Deposits of glass recently spotted on the surface of Mars could hold the key to whether the planet once hosted life.

Observations by NASA's Mars Reconnaissance Orbiter have revealed large deposits of glass in Martian impact craters. On Earth, impact glasses sometimes preserve the signatures of ancient life, including organic molecules and plant matter. It's possible that the Martian deposits could do the same. "We think these could be interesting targets for future exploration," says co-author Jack Mustard of Brown University in Rhode Island. Indeed, one of the craters is near the Nili Fossae trough, a landing site candidate for the Mars 2020 rover.



EUROPE AND CHINA PLAN SUN MISSION

ESA and China have teamed up to develop a joint spacecraft mission to study the interaction between Earth and the solar wind streaming out from the Sun. The spacecraft would launch into an elliptical orbit of Earth in 2021.



THE UNIVERSE'S BRIGHTEST LIGHT

A DISTANT GALAXY brighter than 300 trillion Suns been discovered in observations by NASA's WISE spacecraft. It is the most intrinsically luminous one found to date and belongs to recently discovered class of objects – extremely luminous infrared galaxies.

The galaxy is so distant that its light has taken 12.5 billion years to reach Earth. "We are looking at a very intense phase of galaxy evolution," says lead author Chao-Wei Tsai of NASA's Jet Propulsion Laboratory in California. "This dazzling light may be from the main growth spurt of the galaxy's black hole." Further research will hopefully clarify why galaxies like this became so very bright.

www.nasa.gov/wise

More than 99 per cent of the light emitted by this record-breaking dusty galaxy is infrared

Looking back The Sky at Night

August 1977

On 10 August 1977, the topic for *The Sky at Night* was the constellation of Cygnus, the Swan. This northern constellation lies on the plane of the Milky Way and is one of the easiest constellations to recognise in the night sky.

The programme also discussed one of Cygnus's most distinctive objects, a binary system of dwarf stars called 61 Cygni. They orbit each other every 659 years or so and are visible to the naked eye in dark skies. In 1838, the German astronomer Friedrich Wilhelm Bessel made 61 Cygni the target for the first accurate measurement of a star's distance by the parallax technique. Modern estimates suggest it lies about 11.4 lightyears away.

During the 20th Century, several astronomers reported hints of a massive planet orbiting one of 61 Cygni's stars, but these claims were never confirmed.

No firm evidence has been found for planets around 61 Cygni

NASA/JPL-CALTECH/JHUAPL/UNIVERSITY OF ARIZONA, ESA/NASA - SOHO/LASCO/EIT/NASA/ ESA/STSCI/AND G. BACON, NASA/JPL-CALTECH, ESO ONLINE DIGITIZED SKY SURVEY

CUTTING EDGE

Our experts examine the hottest new research

The light stochastic

The past history of distant stars could have affected the path of evolution on Earth

ISTOCK

▲ It's possible that radiation from supernovae could have speeded up evolutionary 'molecular clocks', putting them ahead of the fossil record

In science, no aspect is completely isolated from another: sometimes research into one area can end up solving a mystery in another seemingly unconnected field. For instance, when biologists are trying to work out the time since two species split from each other, and so calculate dates of branching on the evolutionary tree of life, they can use two different techniques.

First, the fossil of an organism can be dated using the radioactivity of the rocks around it. Alternatively, counting the number of differences in the DNA sequence of two living species allows an estimation of the time since they diverged based on the number of mutations that have accumulated, like a molecular clock. The problem is that the fossil age and molecular clock age don't always agree, and there are particular disparities in the evolutionary tree of the birds.

However astrophysics might have an explanation, says Adrian Melott of the University of Kansas. If the accumulation rate of mutations wasn't in fact constant, then the ticking of the molecular clock would vary over time and throw off the correspondence between fossil dates and molecular ages. A major contributor to mutations in cells is background radiation, from radioactive elements in rocks, for example, but also from cosmic rays striking Earth from deep space. Although the Earth's magnetic field and thick atmosphere do protect the surface from most cosmic rays, particularly violent events such as a nearby supernovae can still send a flood of ionising radiation – muons and neutrons – all the way to the ground. In addition, a supernova can diminish the ozone layer in Earth's upper atmosphere and so allow greater levels of ultraviolet radiation from the Sun to reach the surface. Both this ionising radiation and heightened ultraviolet exposure can damage the DNA in any organism they strike, resulting in a greater mutation rate and so a faster ticking of the molecular clock. As Melott argues, any measurements of the rate of the molecular clock made today, when the Earth is not currently experiencing a heightened radiation hazard, would not include this acceleration.

In particular, Melott points to an increase in the isotope iron-60 in sediments dating back around 2.5 million years; evidence that one or more supernovae went off within a few hundred lightyears of Earth in recent evolutionary history. This event, and similar ones through Earth's past, could have periodically accelerated molecular clocks and so caused the disparity seen between fossil ages and molecular dating methods.

"Supernovae can diminish the ozone layer and allow more ultraviolet radiation to reach the surface"

Melott is quick to clarify that he's not saying this hypothesis is necessarily better than other proposed explanations for these disparities between dating techniques, just that it is a possibility that deserves to be investigated more fully. But like any proper scientific hypothesis, Melott has proposed ways that his idea can be tested.

If it is indeed bursts of radiation from outer space causing an acceleration of molecular clocks, then you would expect that deep-sea life would be shielded from this fluctuating effect and so there should be a much closer agreement between fossil and molecular dating methods.

LEWIS DARTNELL is an astrobiologist at University of Leicester and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

LEWIS DARTNELL was reading… *A possible role for stochastic radiation events in the systematic disparity between molecular and fossil dates* by Adrian L Melott
Read it online at http://arxiv.org/abs/1505.08125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What's on

Our pick of the best events from around the UK

PICK OF THE MONTH

Solarsphere 2015

Penmaenau Farm, Builth Wells, Powys, 14-16 August

Solarsphere brings astronomy and live music together with a festival atmosphere

Solarsphere promises to be one of the great UK astronomy events of the summer – featuring talks, workshops, solar and night sky observing, astro imaging and debate.

The event is a weekend-long festival, with live music running throughout and free camping available for tents, caravans and campervans. Music and catering will be hosted indoors, ensuring light pollution does not disrupt the observing sessions that will be taking place from dusk til dawn over the weekend.

Speakers at Solarsphere 2015 include *BBC Sky at Night Magazine* reviews editor Paul Money, astronomer and writer Will Gater, solar scientist Dr Lucie Green and Dr Megan Argo of the Jodrell Bank Centre for Astrophysics. Cosmos Planetarium will also be on site with a mobile planetarium show, bringing the wonders of the Universe to the Welsh countryside.

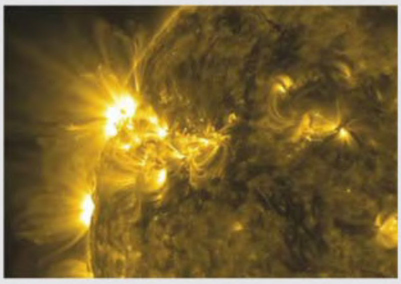
The main events begin at noon each day, with solar observing sessions, space art workshops, balloon-powered rocket racing and more taking place around the site each morning. Tickets are £45 for adults, £20 for 14-16-year-olds and free for under-14s.

www.solarsphere.events

BEHIND THE SCENES

THE SKY AT NIGHT IN AUGUST

BBC Four, **9 August,** 10pm (first repeat BBC Four, **Wednesday 12 August,** 7.30pm)*



Our Sun is a chaotic body, with flares and coronal mass ejections regularly erupting

COSMIC BLASTS

This month, the *Sky at Night* team will be looking at cosmic explosions, with special insight from solar scientist Dr Lucie Green. They will explore the beautiful but potentially deadly outbursts of our star, and the most violent and energetic events in the Universe – supernovae, gamma-ray bursts and the Big Bang.

Check www.bbc.co.uk/skyatnight for subsequent repeat times

Solar Gazing

Wycombe Astronomical Society, Waddesdon Manor, Buckinghamshire, 14 August, 11am

The National Trust's Waddesdon Manor hosts a solar observing event organised by Wycombe Astronomical Society for parents and children. Also planned for the day are kids projects to make a pinhole camera and build a sundial. The event is free to attend, and entry to Waddesdon Manor Gardens is free for National Trust members and under-fives. There is an entry fee for non-members of £8 for adults and £4 for children.

www.wycombeastro.org

Water in the Solar System

Lincoln Astronomical Society, Lincoln Observatory, Lincoln, 4 August, 7.30pm

Liquid water, so important for life as we know it, is a scarce commodity in the Solar System – and yet ice is very common. In this lecture, Michael Czajkowski of the Open University will look at the distribution of water and ice and explain why we find it where we do, the origin of Earth's water, as well as touching upon the workings of the Rosetta spacecraft. Admission is £4 for visitors and free for members.

www.lincolnastronomy.org

Perseid Spotting

Scottish Dark Sky Observatory, Dalmellington, East Ayrshire, 11-13 August, 10pm

The Scottish Dark Sky Observatory is hosting three evenings of meteor watching over the peak of the Perseid meteor shower. The event will include an introductory talk and a tour of the observatory, before attendees get the chance to witness one of the year's top meteor showers. Tickets are £12 for adults and £8 for concessions.

www.scottishdarkskyobservatory.co.uk

MORE LISTINGS ONLINE

Visit our website at **www.skyatnightmagazine.com/whats-on** for the full list of this month's events from around the country.

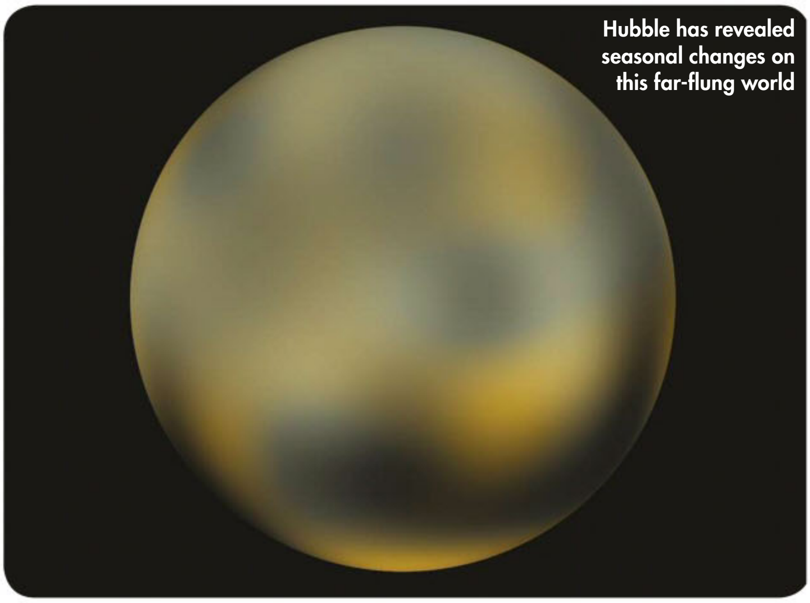
To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the page.

SOLARSPHERE, PAUL PHILLIPS/WYCOMBE ASTRONOMICAL SOCIETY, LINCOLN ASTRONOMICAL SOCIETY, PETE LAWRENCE, SOLAR DYNAMICS OBSERVATORY/NASA.

A PASSION FOR SPACE

with Maggie Aderin-Pocock

The Sky at Night presenter looks back at Pluto's past ahead of its meeting with the New Horizons probe



Hubble has revealed seasonal changes on this far-flung world

NASA/ESA/AND M. BUIE (SOUTHWEST RESEARCH INSTITUTE)

With New Horizons rapidly reaching its point of closest approach to Pluto, it seems a good time for an overview of the dwarf planet's fascinating history to date. First known as the hypothetical Planet X, Pluto's existence was originally inferred from gravitational perturbations on the orbits of Neptune and Uranus. It was discovered, and hailed as a planet, in 1930 by Clyde Tombaugh. However, estimates of Pluto's proportions were too high; they have been plummeting over the century and have now settled at around one-sixth the mass of the Moon and one-third its volume. At this mass it is unlikely that any orbital effects would have been observed, so it seems that Pluto was actually discovered by accident.

After discovery came naming, and a competition was set up. It was won by 11-year-old Venetia Burney, who suggested it should be named after the king of the underworld in classical mythology. The discovery generated much public interest and it is claimed that Disney named Mickey Mouse's canine companion Pluto after it.

Observations of Pluto have been few and far between. This world can lie 7.5 billion km from Earth, and the alignment didn't work for a visit from either of the Voyager spacecraft. In 1978 photographic plates revealed the presence of Charon, Pluto's largest moon; a companion so large that the pair could be considered a binary system. It was not until March 1996, some 66 years after the planet's discovery, that the Hubble Space Telescope was able to take a semi-detailed image of Pluto's surface.

Details trickle in

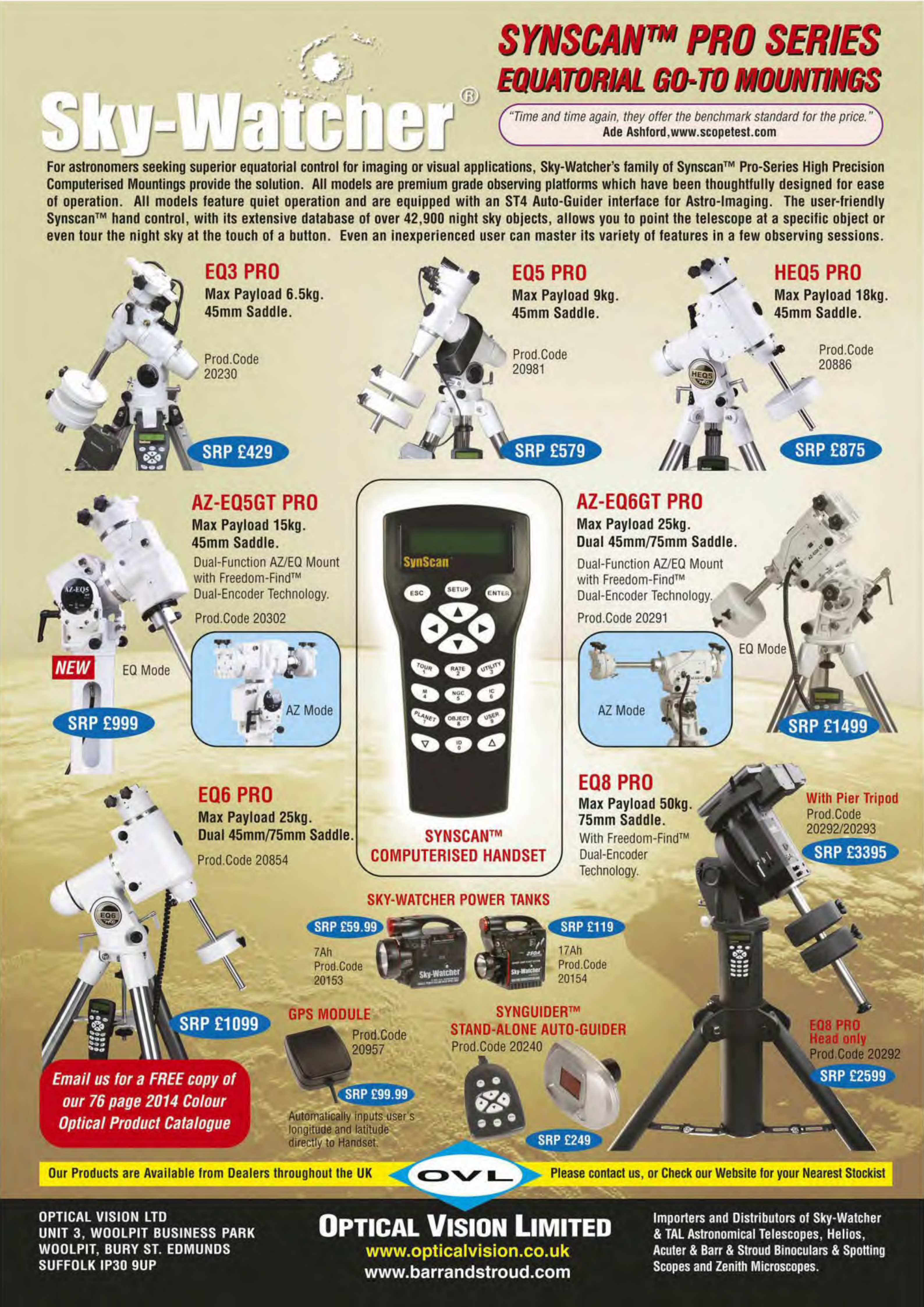
Hubble's imaging campaign was conducted over 6.4 days – a full rotation of the Pluto. The images revealed polar caps and dark patches over the surface. Pluto's moons Nix and Hydra were both discovered in 2005, also using the Hubble Space Telescope.

In January 2006 the New Horizons space probe was launched to fly past Pluto, then the only world in our Solar System that had yet to be have a robotic visitor from Earth. In the same year, Pluto was demoted from planet to dwarf planet – a decision that has stuck, though some debate still continues.

The objectives of the New Horizons mission remained the same: to characterise and analyse the surface, geology and atmosphere of both Pluto and Charon. It will then look for additional satellites beyond the five we now know about before preforming similar tests on other bodies in the Kuiper Belt. But as well as looking forward, New Horizons has paid homage to the past. On board the spacecraft is an ounce of the ashes of Pluto's discoverer Clyde Tombaugh.

In the near future we will have a much better understanding of Pluto and its companions, but for now I'm looking forward to sharing the excitement of this historic moment in an hour-long *Sky at Night* special report (BBC Four, 20 July, 10pm) direct from New Horizons mission control during the flyby. S

Maggie Aderin-Pocock is a space scientist and co-presenter of *The Sky at Night*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JON CULSHAW'S EXOPLANET EXCURSIONS

Jon visits a Neptunian world surrounded by an asteroid belt that dwarfs our own

There's an understated star with the designation HD 69830 in the quirkily named constellation of Puppis. Although this orange-glowing, seven-billion-year-old star is too southerly to be seen from UK skies, it's very much worth a trip because of an astonishing feature encircling it: the most colossal asteroid belt. Detected in 2005 by NASA's infrared Spitzer Space Telescope, this asteroid belt is 20 times more massive than the one between Mars and Jupiter in our Solar System.

It's the kind of environment envisioned by Atari back in 1981. To navigate safely to my destination I'll have to steer the Perihelion ship with the skill of Han Solo.

Of the planets known to exist in this system, I'm heading for HD 69830 d, nestled in the habitable zone. This world takes 197 days to complete an orbit at a distance of 0.6 AU from its parent star. It's a rather Neptunian planet, around 18 times the mass of Earth, and there doesn't seem to be a solid enough surface on which to land. What's more, the strength of gravity on this world would be sufficient to contort my facial expressions into a permanent state of Les Dawson. So I'm landing on an icy moon close by to give a steadier, terrestrial base to observe from.

The glow from star HD 69830 marinades all of the bodies in the system in a rich golden hue reminiscent of an Andalusian evening seen through bronze-coloured sunglasses. From the moon, HD 69830 d boldly appears top-half only, like an imposing curved mountain of emerald and earthshine blue. Its blend of blues and greens is midway between Neptune and Uranus, so 'Uratune' seems a fitting name for this resplendent planet.

Soon, as the alien sky deepens in darkness, the spectacular effects of the massive asteroid belt become breathtakingly visible. The volumes of residual dust created by a belt of this magnitude give rise to a zodiacal light around 1,000 times brighter than our version visible from Earth. Back home we see the 'false dawn' of the zodiacal light as a quietly beautiful, eerie glow veiled through the night sky like a cone-shaped ghost. From the surface of the Uratunian moon, this system's zodiacal light is more like a searchlight beam .

It's a staggering view of the giant asteroid belt. The first comparison that flashes to mind is a view of the Milky Way observed from the darkest Earthly deserts. But the visual texture of this asteroid belt is coarser and thicker, as though our Milky Way has been redrawn with chunky Ceefax graphics.

Viewed through the comet hunter binoculars I keep in the Perihelion's glove box, shapes, features and texture on many individual asteroids can be made out. It's amazing to behold the brightening bronze to gold shades of these jagged-edged space rocks as they arc upwards into the alien night sky.

This magnificently robust asteroid belt, four other neighbouring moons, a zodiacal light of such luminosity you'd think it was close to igniting and the planet Uratune setting with silent authority: what a crowded and glorious alien night sky!

Jon Culshaw is a comedian, impressionist and guest on *The Sky at Night*

MAIN ILLUSTRATION: MARK GARLICK, SPACECRAFT: PAUL WOOTTON, PHOTO: EMMA SAMMS

This month's top prize: four Philip's books

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Heather Couper and Nigel Henbest's *Stargazing 2015*, Patrick Moore's *The Night Sky*, Storm Dunlop's *Practical Astronomy*, and *Stargazing with Binoculars* by Robin Scagell and David Frydman.

PHILIP'S

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MESSAGE OF THE MONTH

Anyone can achieve what I have here

▲ David's ingenious additions of twin pods on the side of his dome allow for some storage and a computer space

Having seen the letter from Stephen Charnock on constructing an observatory in your January 2015 issue (*Interactive*, page 24), I was inspired to give the project a go. The end result took exactly four months from digging the foundations to completion, and I incorporated several adaptations as I went along. The best of these is the provision of two 'pods', one for storage and one to house a desk for my laptop. I'm now looking forwards to some dark nights.

The benefits of being enclosed and having everything to hand, while being able to set up or finish in a couple of minutes, cannot be overstated. The project is well within the capabilities of an average DIYer and the only thing I found daunting was fibre-glassing the dome, but even this wasn't too difficult with careful research and planning, and a knowledgeable helper.

David Murton, Ipswich

Congratulations David, a wonderful example of workmanship. Here's to many happy hours under your new dome! **– Ed**

I couldn't believe it

I live in a relatively rural area, so always believed myself to be fortunate in having a good view of the night sky. However, after a visit to Snowdon I can honestly say that until that moment I have never truly seen stars before, or at least in that abundance. It was like someone had taken a paint brush and splashed it all across the dark sky many times over; they were so defined and beautifully crystal clear. It was an image I will never forget and long to see again. This as a result has inspired me to pick up your magazine.

Anna Victoria, Herefordshire

Thanks for sharing your inspiration Anna. What would the world be like if everyone had access to skies as dark as that? **– Ed**

Here be dragons

Back on 14 April I saw one of the strangest sights I have ever seen while stargazing. I had travelled to Cheddar to test my new DSLR's capabilities on wide star fields, when I saw three bright lights moving across the sky in a straight line like an Iridium flare. I immediately looked through binoculars to discount it being a plane and then spun my camera around on the tripod very quickly (hence the wobble at the start of the track in the image) to capture a 30-second exposure.

The light in the middle was easily as bright as the ISS, which had passed over about 40 minutes prior, and the lights either side were about half the brightness. You can see from the picture that they fade out towards the end of the exposure, exactly like an Iridium flare. I have since found out that this was the SpaceX Dragon rocket heading to the ISS!

SOCIAL MEDIA

WHAT YOU'VE BEEN SAYING ON TWITTER AND FACEBOOK

Have your say at **twitter.com/skyatnightmag** and **facebook.com/skyatnightmagazine**

@skyatnightmag asked: what are you most looking forward to seeing from the New Horizons Pluto flyby?

@sjb_astro As all Solar System missions have resulted in unpredictable discoveries I expect nothing but revelations!

Graeme Burdis Active surface detail...

@ScottPhillips11 Something we didn't expect.

SOCIAL MEDIA

WHAT YOU'VE BEEN SAYING ON TWITTER AND FACEBOOK

Congratulations to the winners of our 10th anniversary competition run in the June 2015 issue. Each receives a copy of the very first edition of *BBC Sky at Night Magazine* complete with coverdisc and pull-out Moon map.

@RockersAndrew

@JennyMayQueen

@oo03par

@Cahlyn2230

The bright light in the middle was the main rocket, and either side were the solar panel covers that had just been jettisoned. This is why I love astronomy: I just headed out to take some very amateur wide-field photos and I ended up capturing a rocket flying overhead!

Jack Lee, via email

What an awesome observation, Jack. Kudos for having the presence of mind to grab photographic evidence. ***– Ed***

▲ **Jack caught the rocket's tell-tale trail by chance – proof that fantastic sights do occur when least expected**

I wandered lonely on a...

With the comet lander Philae back in the news, it got me thinking about what a lonely existence a comet must lead. This poem touches on that idea:

Hyperbolic

Am I ice and dust?
You tell me so.

Infrequently I pass,
flexing when I close encounter,
feel the friction.

That is when your gravity,
meagre, sufficient,
slingshots me away.

Out into the absence of something,
deep into the elation of nothing.

C M Buckland, via email

How well these few lines of beautifully chosen language mirror the emptiness and isolation of deep space. ***– Ed***

Patrick's legacy lives on

Here in Plymouth, we recently ran a city-wide competition for young people to photograph or paint a picture of the Moon in honour of the late Sir Patrick Moore. The Marine Academy Plymouth's Moore Moon Mission was a great success, with entries from more than 140 students aged between six and 16, and 23 different schools. Members of the Plymouth Astronomical Society had a challenge when it came to judging the winners, who received engraved shields and medals, pens and keyrings donated by the British Astronomical Association, as well as copies of *The Universe According to Sir Patrick Moore* special issue that you donated.

Kallum Hoskin from Eggbuckland Community College won first prize for secondary school students and Imogen Godfrey of Plymouth College Preparatory School took first place for the primary school age group. We will run the competition again next year and hope to get even more entries.

Martin Edmonds, Plymouth

Patrick would have been delighted that you are encouraging the young people of Plymouth to discover the Moon and stars. Well done! And if you missed our The Universe According to Patrick Moore *special edition in the shops, you can buy it online. See* ***www.skyatnightmagazine.com/universe-according-patrick-moore****.* ***– Ed***

▲ **The lucky winners with their engraved medals alongside teacher Martin Edmonds**

How far can I go?

▲ **Chris's snap of galaxy IC 2745 in Leo – it is almost half a billion lightyears away**

My son recently challenged me to photograph the most distant astronomical object possible with my modest equipment – a Sky-Watcher 130PDS Newtonian on an EQ5 mount, with a Canon EOS 1100D DSLR camera. I have so far managed the galaxy IC 2745, at an estimated distance of about half a billion lightyears, which I captured in the background of a photograph I took a few of weeks ago of the Leo Triplet of galaxies. Imaging a quasar would push the distance beyond the billion lightyear mark, but I'm waiting until August and properly dark skies before I attempt that.

Chris Duffy, Consett, County Durham

Clearly you have the skills to match this great challenge, Chris! If it's a quasar you're after, how about 3C 273 in Virgo, at two billion lightyears? ***– Ed***

Hotshots

This month's pick of your very best astrophotos

▲ M81 and M82

ÁLVARO IBÁÑEZ PÉREZ, CORRAL DE ALMAGUER, TOLEDO, SPAIN, 25 MAY 2015

Álvaro says: "Corral de Almaguer is in the south of Madrid, so these objects are normally obscured by the light pollution from the capital. As a result, I had to use an IDAS anti-pollution filter. In terms of the clarity of the night sky, that evening everything turned out perfectly."

Equipment: Atik 460EX mono CCD camera, TS115 triplet apo refractor, NEQ Pro II tuning belts and EQMOD, Baader LRGB and IDAS LPS filters.

***BBC Sky at Night Magazine* says:** "The level of clarity in this image, particularly spiral galaxy M81 on the right, is astounding. Considering Álvaro has only been photographing for a short while, this image should be an encouragement to anybody thinking about starting out in astrophotography."

About Álvaro: "I got into astronomy around 2012 at my grandparents' house while looking at the Moon through the viewfinder of a DSLR. I have now been taking astrophotos for two years; first with a DSLR and now a CCD camera. As I live in Madrid, which has a lot of light pollution, I often have to travel over 200km to take photographs of good quality.

▲ Lunar crater Copernicus

PETER LOUER, TENERIFE, SPAIN, 29 MAY 2015

Peter says: "The caldera in the Parque Nacional del Teide is a perfect dark site set at an altitude of around 2,000m. I can take pictures like this as a single shot without the need to stack multiple frames."

Equipment: Canon EOS 700D DSLR camera, Meade ETX 105 telescope.

▲ The Cave Nebula

CHRIS HEAPY, MACCLESFIELD, 31 MAY 2015

Chris says: "While it is difficult to observe the Cave Nebula visually, given adequate exposure and the power of a modern astro CCD camera it makes for a beautiful image."

Equipment: Atik 490EX CCD camera, Tele Vue NP127is refractor, Losmandy G11 EQ mount, Tele Vue Pronto and Lodestar guides.

▼ Star trails

PAT DUFFIELD, EXMOUTH, 7 JUNE 2015

Pat says: "The finished image is a collection of 300 30-second exposures stacked together. It was a full clear night, but a bright Moon also, so I wanted to test this technique to show how much we spin in space over a short time."

Equipment: Canon EOS 1100D DSLR camera, Samyang 24 mm f/2.4 lens.

▼ Waxing crescent Moon

CALLUM PENNINGTON, ST HELENS, MERSEYSIDE, 23 MAY 2015

Callum says: "This is quick image I took of a waxing crescent Moon. The image is laterally inverted since I use a reflector and I had to alter the exposure of my mobile phone in order to capture it."

Equipment: Smartphone, Sky-Watcher Explorer-130 Newtonian reflector, EQ2 equatorial mount, HookUpz universal smartphone adaptor.

▲ Southern hemisphere night sky

JOHN SHORT, THE GLASS HOUSE MOUNTAINS, QUEENSLAND, AUSTRALIA, 15 JANUARY 2015

John says: "It's amazing how difficult it is to recognise even well-known constellations when they are upside down in the sky."

Equipment: Canon EOS 6D DSLR camera, 8-15mm fisheye lens.

▲ The North America Nebula

DAVID SLACK, NEWCASTLE UPON TYNE, 6 JUNE 2015

David says: "I tend to image nebulae mostly as I can use narrowband filters to get better results from my city location. NGC 7000 has some nice bright detail in the Wall area and an attractive starfield."

Equipment: Canon EOS 1100D DSLR camera, Starlight Xpress SXV-H9 CCD camera, Revelation 2.5-inch doublet, Sky-Watcher HEQ5 Pro mount, Altair Astro 0.8x focal reducer.

◀ The Crescent Nebula

PATRYK TOMALIK, GLOUCESTER, 17 MAY 2015

Patryk says: "It took four nights to make this photo. Despite capricious weather and moonlight I managed to get six hours of exposures for hydrogen-alpha and six hours for OIII."

Equipment: SBIG ST-8300 CCD camera, Sky-Watcher 120ED refractor, Sky-Watcher 0.85x focal reducer, Sky-Watcher AZ EQ6-GT mount.

The Cocoon Nebula ▶

MARK GRIFFITH, SWINDON, 22 APRIL 2015

Mark says: "I used a 30-minute field of view to capture some of the dark nebula within the Cocoon Nebula. The pink colour is due to the mix of reflection and emission nebulae."

Equipment: Atik 383L+ CCD camera, 12-inch Ritchey-Chrétien telescope, Sky-Watcher EQ8 mount, Astronomik LRGB filters, Hutech IDAS light pollution filter, Astro-Physics 0.67x focal reducer.

▲ Rising galaxy

ANVAR GHADERI, KURDISTAN, IRAN, 26 APRIL 2015

Anvar says: "This photo was taken on a starry night in a village between two cities that give off a lot of light pollution. They can be seen in the distance, with Baneh on the left and Armerdeh on the right."

Equipment: Canon EOS 5D DSLR camera, 14mm Samyang lens.

ENTER TO WIN A PRIZE!

ALTAIR ✶ ASTRO We've joined forces with Altair Astro UK to offer the person behind next month's best *Hotshots* image a fantastic prize. The winner will receive an iOptron SkyTracker camera mount, designed to keep your camera tracking at the same speed that Earth rotates. www.altairastro.com • 01263 731505

Email your pictures to us at hotshots@skyatnightmagazine.com or enter online.

WARNING

Never look directly at the Sun with the naked eye. Always use certified eclipse glasses or equipment fitted with a proper solar filter.

▲ Hydrogen-alpha light reveals the Sun's roiling chromosphere and its myriad details

▲ Some prominences are delicate, but others form vast interlinked 'hedgerows' as seen here

WILL GATER X 5, PAUL WHITFIELD, ISTOCK

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

If we inspire you to give solar imaging a go with this feature, why not enter your finished images into the Insight Astronomy Photographer of the Year competition? From this year, solar images like the ones we show you how to take here have their own category. The 2015 winners will be announced in September, while the 2016 competition opens in January next year.

MAKE THE MOST OF SUMMER SOLAR OBSERVING

Will Gater reveals how to get the best out of observing and imaging with the Coronado Personal Solar Telescope

If the short nights at this time of year have got you in the astronomical doldrums, take solace from the long, warm days that precede them: summer is a fantastic time to explore our nearest star. And there are lots of ways to do it too. As well as traditional white light solar filters, today there are also several dedicated solar telescopes and specialist filtering systems on the market. In this feature we'll be looking at a solar telescope that's used by many societies and amateur astronomers, the Coronado Personal Solar Telescope (PST). We'll be focusing on the hydrogen-alpha model, which shows just the hydrogen-alpha light emitted by our star, revealing its ever-changing chromosphere. We'll show you what you can see with the PST and offer a step-by-step guide to imaging with it. Before you know it, you'll be hoping the summer never ends.

GET TO KNOW THE PST

EYEPIECE HOLDER

The eyepiece holder for the PST is located on the top of the telescope's main body. It accepts 1.25-inch eyepieces and nosepieces for high frame rate CCD cameras or webcams.

FINDER

The PST is equipped with a simple finder, which works by projecting a bright spot onto a small circular screen. Centre the spot in the screen and the Sun should be in the eyepiece.

TUNING RING

The ring around the base of the telescope's tube allows you to tweak the tuning of the PST. By slowly rotating this ring you can view different features.

MAIN BODY

The body of the PST is home to vital parts of the telescope's filtering system, including the etalon. This system picks out just the hydrogen-alpha light from the Sun, revealing its seething chromosphere.

FOCUSER

Focusing the view of the Sun in the eyepiece of a PST is achieved by carefully turning a small, cylindrical knob located at the rear of the telescope assembly.

BASE

The PST's base has two threaded holes – much like the one you'll find in the base of most DSLRs. This makes attaching it to a photographic tripod plate quick and easy.

IMAGING MADE EASY

We show you how to create a hydrogen-alpha image showing both prominences and disc detail using a PST, laptop and high frame rate CCD camera

1 SET UP AND ALIGN YOUR MOUNT

Set up your laptop and camera, as well as the mount you'll be using to carry the PST. If you're using an equatorial tracking mount try to get it roughly polar aligned, as this can help with tracking. In the daytime this may mean simply making sure the north leg is indeed pointing north. You can use a mount with manual controls too; we've even had moderate success imaging with the PST mounted on a photographic tripod, though these methods require patience and a steady hand.

2 SELECT SOLAR TRACKING MODE

Some mounts can track the sky at the rate the Sun moves across it. For example, if you have a Sky-Watcher mount with a SynScan handset you'll find this option via the 'Setup' menu. Even if your mount has this function, it's a good idea to monitor the feed from your camera on the laptop screen to make sure the feature that you're imaging isn't drifting too much, as severe movement can ruin a picture. Some image capture programs have a reticule overlay that can help with this.

3 MOUNT THE PST

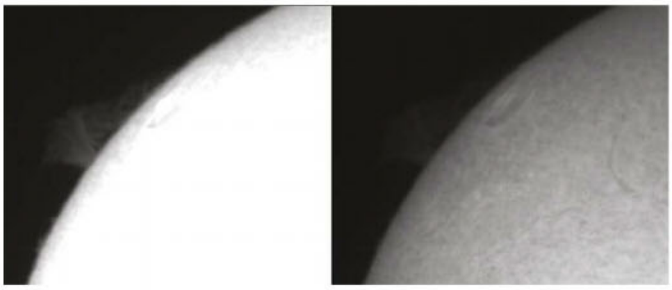
Attach the PST to the mount head. The base of the telescope has holes in it that can be used to attach a dovetail bar. You can then securely fit this bar straight to the mount. If you're using a photographic tripod you can screw its mounting plate into one of the holes, as you would if you were attaching a DSLR. Now's also a good time to secure your webcam or CCD camera in the eyepiece holder.

4 FIND THE SUN

Next you need to get the Sun in the field of view of the camera, using the PST's finder to locate the Sun safely. Without looking at the Sun, turn the telescope in the rough direction of it. This should cause a dot of light to appear on the circular finder screen. Using the handset or controls on your mount, move the PST so this little dot is centred. The Sun should then be in the camera's vision.

5 COMPOSE AND FOCUS

Let's start thinking about composing the shot. If you're imaging a specific feature, consider how you're going to present it. Do you need to rotate the camera to fit in all the features you want to capture? If you do, note the alignment of the field of view with respect to the directions your mount moves, just in case you need to tweak the tracking while imaging. Once you've decided on the composition, lock the camera in place and confirm the image is in focus.



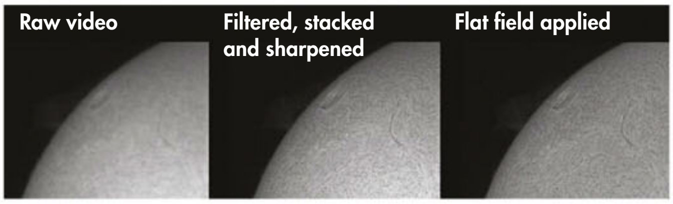
6 SET THE EXPOSURE

In this tutorial we're showing you how to produce an image revealing the detail on the Sun's disc as well as prominences on the limb. To do this we need to create two images from videos with different exposures and combine them together. This means that in the next step you should begin by capturing one video that is exposed for just the disc detail. Then you need to capture another video, this time with the exposure increased to bring out the fainter prominences.

ALL PICTURES: WILL GATER

7 CAPTURE THE VIDEOS

Now let's capture the two AVI videos that we're going to process into our still images for combining. Try to capture between 1,000 and 2,000 frames for each video. High frame rate CCD cameras work best here as they can capture many frames in a short period, allowing you to catch those rare moments of good seeing. Don't worry if the disc of the Sun is completely overexposed in your second video (the one exposed for the prominences), as the disc from that image won't actually be visible in the final composite.

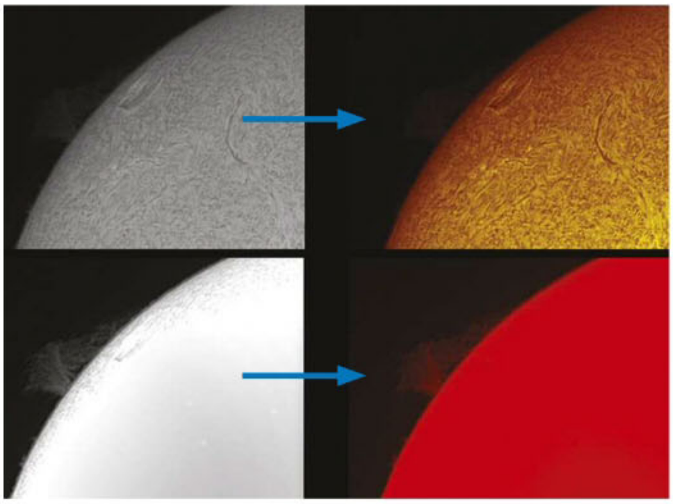


9 PROCESS THE VIDEOS

Now we need to take the three videos and process them in software such as RegiStax. RegiStax can filter and stack the best frames from the prominence and disc videos as well as wavelet sharpen the still images that this process produces. It can also create and subtract the flat field frame. To create a flat field, open the flat field video and use the Flat/Dark/Reference > Create Flatfield menu. Save the image this creates and apply it (using Load Flatfield) to the two processed main images.

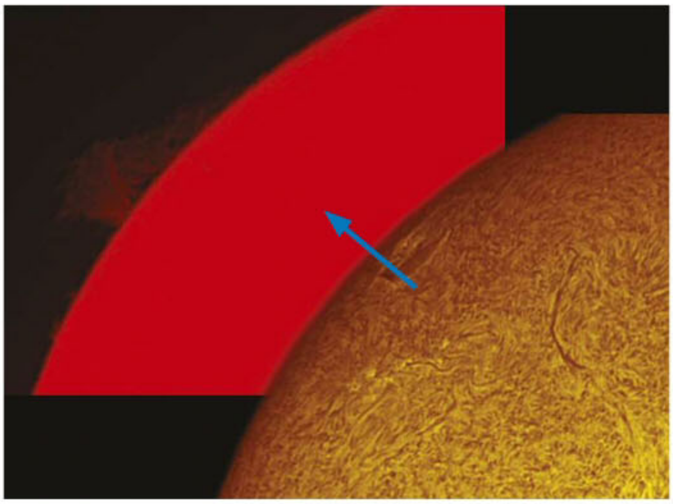
8 DEFOCUS AND CAPTURE A FLAT FIELD

When imaging with the PST you may notice gradients across the disc of the Sun. We can go some way to removing these by capturing a sort of flat field calibration image. First point the PST at a featureless region close to the middle of the Sun (away from the limb) and set the exposure settings to those you previously used to image the disc. Next defocus the scope so that the disc is completely blurred. Finally, capture a video of a few hundred frames.



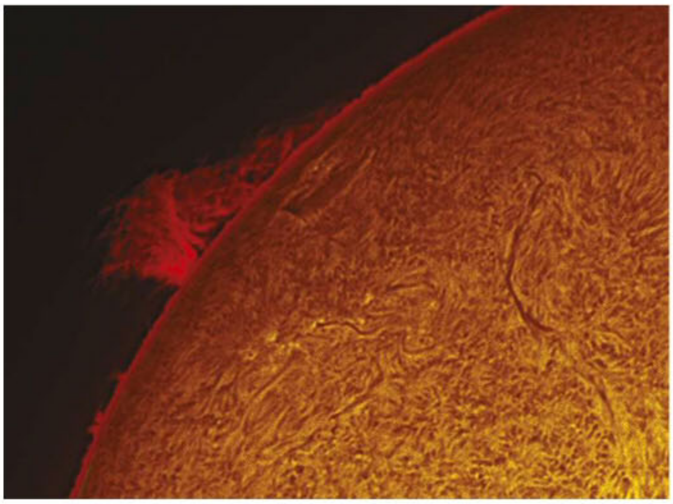
10 COLOURISE THE IMAGES

By now you should have two still images (ideally saved as PNG files), which we're going to process further. Most solar imaging is done with a monochrome camera so the next step will be to colourise the two images. Photoshop or GIMP is ideal for this. Open the images and select the Levels adjustment tool. Now adjust the various sliders for the different colour channels (mainly blue and green for the disc image) to achieve the look you want.



11 COMBINE THE TWO IMAGES

Once you have colourised and flat-field calibrated your prominence and disc images it's time to combine them into one image. In Photoshop or GIMP, use a selection tool to select just the dark sky beyond the Sun's limb in the image you've captured of the disc. Feather the edges of this selected area by a few pixels and then delete that portion of the image so that the sky region is now transparent. Copy this as a new 'disc only' layer into your prominence image.

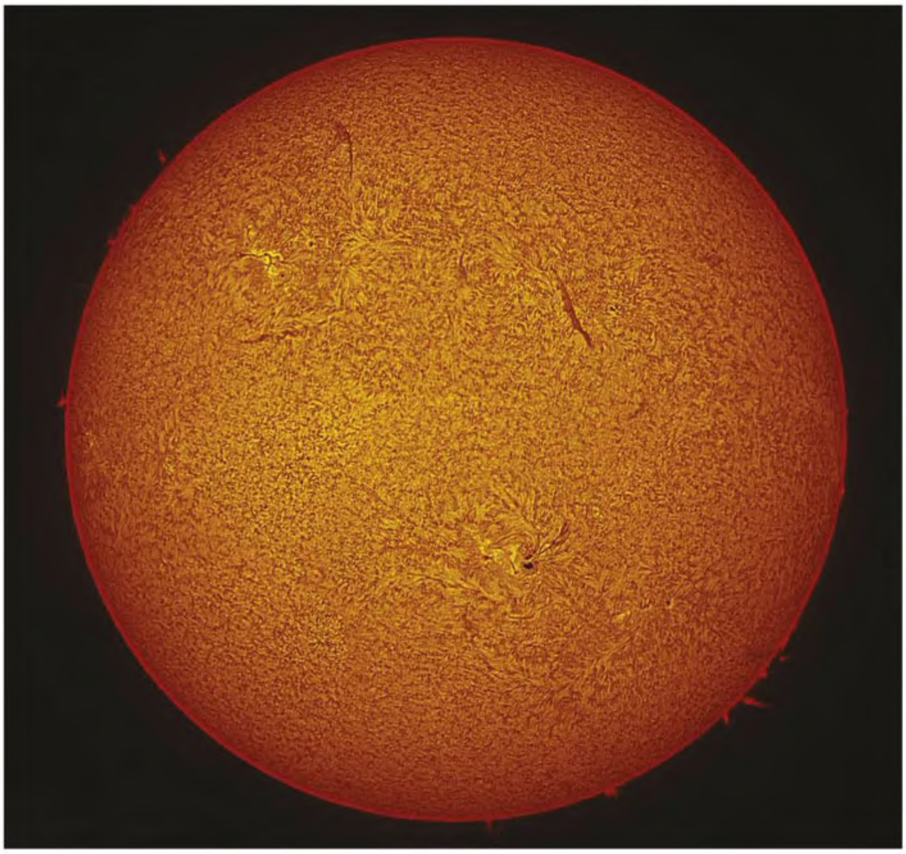


12 FINAL PROCESSING AND SHARPENING

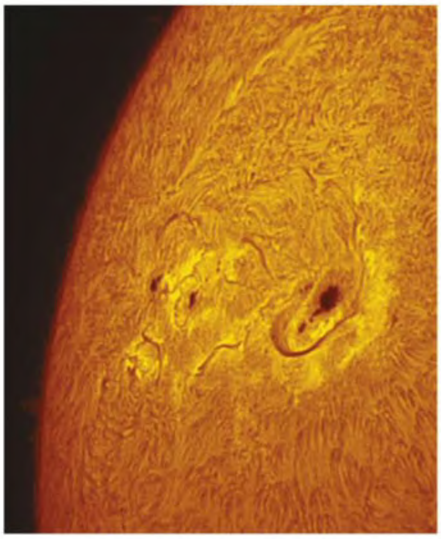
We now have an image, made of two layers, that shows both prominence and disc detail. At this point it's worth checking that the solar limbs in both the prominence and disc layers are correctly aligned with each other. Now the two images are together, you may also find that you want to fine-tune their colours and crop out any unwanted edges. Once you're happy with the image, merge the layers. Lastly, a gentle unsharp mask can make fine details pop out.

WHAT TO LOOK FOR

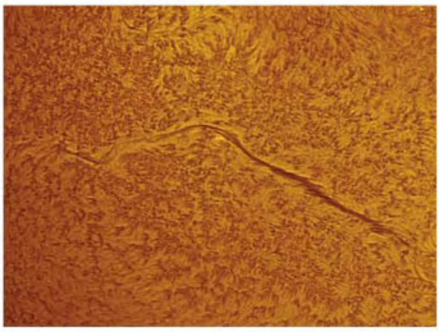
The solar features waiting for you when observing the Sun in hydrogen-alpha light



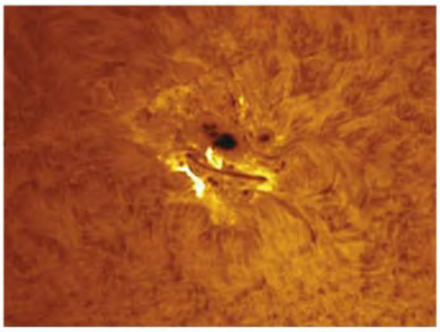
▲ **TEXTURE ON THE DISC**
If you look carefully at the Sun's disc through a hydrogen-alpha filtered telescope you'll notice that, rather than being perfectly smooth, it appears to have a texture that resembles the fibres in a thick-pile carpet. Under periods of good seeing and using moderate magnification this texture is particularly noticeable and images will show it clearly. The 'fibres' often create intricate formations around large active regions.



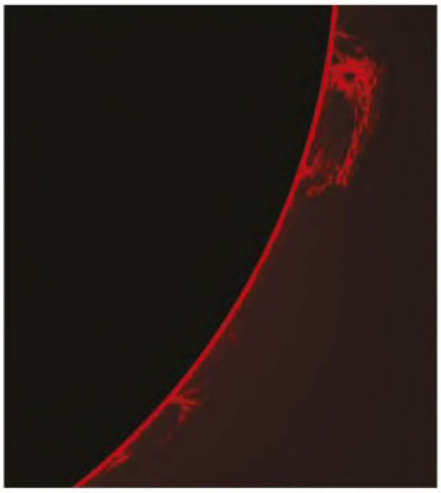
▲ **ACTIVE REGIONS**
Areas on the Sun with particularly complex and intense magnetic activity are known as active regions. At their heart you'll often find the dark core of a sunspot or a sunspot group. The regions themselves are usually permeated by mottled, light blotches where the chromosphere appears much brighter than its surroundings, a phenomenon known as 'plage'. In order to identify them, active regions are assigned numbers by the US National Oceanic and Atmospheric Administration.



▲ **FILAMENTS**
On most days the Sun's disc is marked by several dark, wiggly streaks at hydrogen-alpha wavelengths. These features, called filaments, are simply prominences seen in silhouette. Like prominences, filaments come in many different shapes and sizes. Some are relatively diffuse while others are long and narrow, appearing almost snake-like. Some filaments can be huge, stretching across a substantial portion of the solar disc.



▲ **SOLAR FLARES**
The fun of observing with a hydrogen-alpha solar telescope is that you never know what you might see. If you're really lucky you may witness a solar flare. These violent events are the result of a tremendous release of energy by magnetic fields on the Sun. Through a PST they typically look like an exceptionally bright patch (or patches) within an active region. It's a real thrill to see one appear and fade away while you watch.



▲ **PROMINENCES**
Of all the phenomena visible through a hydrogen-alpha solar telescope prominences are surely the most fascinating to observe. These vast, towering clouds of plasma extending from the limb of the Sun take on many forms, from huge flame-like protrusions to long 'hedgerows' and even great looping arcs. Some visibly change shape over the course of tens of minutes as the material in them moves along magnetic field lines.

WILL GATER X 7

OTHER EQUIPMENT

The PST is not the only way to view the Sun – here are three more options

DAYSTAR QUARK HYDROGEN-ALPHA EYEPIECE FILTER

This eyepiece-end filter allows you to convert an f/4-f/9 refractor into a solar scope. If your scope's aperture is over 3 inches, you'll also need an energy rejection filter for the front lens.

LUNT SOLAR WEDGE

The solar or Herschel wedge is used to refract the light from the Sun away from the optical path of your eyepiece for safe solar observing. Use a solar wedge in your refractor to get stunning white light views.

BAADER ASTROSOLAR BINOCULAR FILTERS

These ready-made filters offer safe white light views and are available in diameters from 50mm to 100mm in 10mm increments. They can also be used with a camera.

SAVOURING THE SUN

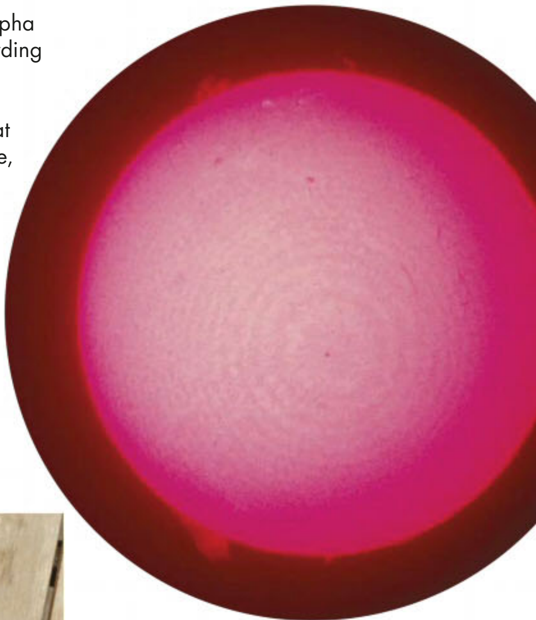
Viewing the Sun through a filtered eyepiece is also a great way to observe our star

Observing the Sun using a hydrogen-alpha filtered telescope is tremendously rewarding and using the PST is no exception. The dynamic nature of the Sun as seen at hydrogen-alpha wavelengths means that from hour to hour, even minute to minute, the view changes as features in the chromosphere evolve and develop.

Sketching can be a satisfying way of recording what you see in the eyepiece. You can get pleasing results using thick, black artist's paper and a red pastel pencil. If you don't fancy drawing the view yourself then you can – with a steady hand and a bit of careful positioning – take a picture using a PST by holding a smartphone's camera lens up to the eyepiece. The image above was captured using this simple technique and shows a number of active regions peppering the Sun's mottled disc as well as several large prominences.

Throughout this feature you'll see that we've included many images taken with a PST.

▲ An alternative to imaging is sketching the view – try black paper and a red pastel pencil



▲ Afocal smartphone imaging can give good results – though you'll need a steady hand

Generally – and this is true of most images captured with a hydrogen-alpha filtered telescope – these pictures show the Sun with an orange-yellow disc and sometimes even orange coloured prominences. The actual view through the eyepiece of a PST is quite different, however. There the Sun's disc, as well as the prominences on the limb, appear a single deep red hue – the distinguishing colour of the hydrogen-alpha wavelength.

The yellows and oranges you see in images taken with hydrogen-alpha telescopes are artificial. These pictures have typically been taken with a monochrome CCD camera and the colour is then later added in the processing stage. This is why you'll often see many different colour palettes in hydrogen-alpha images of the Sun – it's largely down to the photographer's personal preferences and style, or what details they want to bring out.

ABOUT THE WRITER

Will Gater (@willgater) is an astronomer and writer. He is the author of several books and presents live astronomy shows for Slooh.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AN ASTRONAUT'S VIEW OF EARTH

NASA astronaut Chris Hadfield explains the allure of imaging our Pale Blue Dot from low-Earth orbit

What is it like to float above Earth, looking down at our tiny planet in the blackness of space? It is an experience few of us will ever have, but for the astronauts aboard the International Space Station this is the environment they live in, and it makes a big impression. Seeing Earth from orbit, having that connection with home while they're away, is so important to astronaut morale that the Cupola – a module of seven windows facing Earth – was installed in February 2010. To understand this need we talked to commander Chris Hadfield, whose six-month mission to the ISS lasted from December 2012 to May 2013. While there, he not only gazed down at our planet, but took over 45,000 images, sharing them with us back on Earth via the internet. We interview him on page 40, then on page 42 we take a look at a selection of breathtaking images taken from the ISS by other astronauts.

Installed in 2010, the Cupola offers 360° views from the ISS. Here, astronaut Tracy Caldwell Dyson gazes out of the panoramic gallery shortly after it was fitted

NASA/ESA, ISTOCK

"There's a childlike glee in seeing the planet and it immediately surpasses whatever it was you were expecting"

What makes astronauts reach for the camera when they go into space? We caught up with **Chris Hadfield** to find out

INTERVIEWED BY ELIZABETH PEARSON

How did it first feel when you looked down and saw the Earth from orbit?

It's a big event in your life, to fly a rocket to space. The ride is not only extremely dangerous but very demanding physically. It's been the focus of your life for several years, but it's also the result of dreaming and studying, and years of preparation.

But the second the engine shuts off and you're weightless orbiting the world, the absolute compulsion of everyone onboard is to get yourself unstrapped, take your helmet off and go and look out the window.

There's a childlike glee in seeing planet Earth and it immediately surpasses whatever it was you were expecting. The speed of it, the constant change of it. If you wait just another minute, you're over another continent. And because you are going so fast [the ISS travels at 7.66km/s] the angle between you, Earth and the Sun is constantly changing, so the light is constantly changing. The textures that you see and the colours that are brought out with those textures are constantly changing too. So it's like a kaleidoscope, an amazing combination of time-driven events and actual visual impact. You perpetually feel a sense of privilege. It's almost like a sort of reverence as you pull yourself over to the window and see the world passing by.

▲ Early astronauts had to smuggle cameras into space; now they are routinely taken up

Did you immediately feel the need to capture this on camera or did that come later?

NASA doesn't assign one second of working hours to taking pictures of the world. Their experience is that we're going to do that in our free time anyway. Even the Gemini astronauts smuggled cameras to space because NASA said there were only so many ounces available and it didn't want them wasted on pictures. Eventually crews got Hasselblads in 1962.

At a personal level you want to record what you are seeing; you don't want to let it pass by, but you also feel a sense of responsibility for everyone else. You are not there on behalf of yourself alone, you're there on behalf of millions of people who would love to be there also, so there's a sense of being a responsible photojournalist yourself.

You did a lot of outreach work while you were up there; was this something you always intended to do?

I was thinking about that recently and it occurred to me that what inspired me was when we walked on the Moon when I was a little kid. That inspired millions of people; I was one of those. The Apollo programme had an enormous impact on

NASA X 2, CANADIAN SPACE AGENCY AND NASA/YOUTUBE, CHRIS HADFIELD TWITTER ACCOUNT X 6

people that was perhaps never anticipated. As a nine-year-old in rural Canada, I was inspired by that. And I made significantly different choices in life than I would have done otherwise because of how they chose to share an amazing new human experience.

It established in my mind what happens when you're doing something rare. You don't just keep it to yourself smugly and say "Yup, I did this and you didn't". You try to share it. I tried to do it on my first two spaceflights, but the technology got so much better on the ISS. I made almost 100 videos that have been viewed tens of millions of times. People are just curious about it all. But all of that was just a continuation of what I'd seen as a kid with the Moon landings.

Hadfield performs a science experiment designed by students during an outreach show

How did you go about choosing the images for your book *You Are Here: Around the World in 92 Minutes*?
I took about 45,000 images. Some of them are not particularly interesting artistically. Some of them are scientifically, historically or culturally interesting. After doing that I still had thousands of interesting pictures so I went through and decided which of these I would want to show to someone who was sitting beside me at the window. If we were there with our noses pressed against the glass and we've got one orbit of the world, what would I want to show you?

Did you find yourself planning ahead to see any specific things?
Every single day one of the things I would do, if I could find the time, was look at what our proposed ground track of the day was going to be. For instance I wanted a picture of the capital of Brazil. So I put Brasilia into the predictor and then it would tell me when we were over Brazil, but in five months I never got a good picture of Brasilia. It was either dark, or cloudy or I was busy. I never got the picture I wanted!

Some pictures took months. The Panama Canal is always cloudy. There was one day when the photography team at NASA begged us to try and get complete pictures of it because the weather there was perfect and that just never happens. So I did get a picture of the whole Panama Canal.

There were things I wanted to get a picture of, like Mecca and Ayers Rock in Australia. I wanted some big things like Niagara Falls and the Great Wall of China – which by the way you cannot see from space! But most of the pictures I took were coincidence. I just knew we were going to be crossing somewhere and got myself to the window and then just waited and looked around like some sort of hunter. Looking for where the Sun went, looking for something different, some contrast, some strange shape.

Once you were up there and regularly looking down, did you find it difficult to learn your way around the globe?
No. It's harder on the surface! From up there, there are some things that look like an atlas. And you recognise things. It's very different in that the lighting is imperfect, weather patterns block things and north isn't up. But you get to know the whole world quite well. Then you get to have favourite places and think 'I want to photograph that place when it comes around again'. Or in two weeks that glacier will have changed, or the season will have changed. It's like when you move to a new city. At first, all of it is amazing. Then you get to know all the nooks and crannies, and you get to really know the place. That's how I feel about the whole world.

Turn the page for some of the very best images of Earth captured by ISS astronauts, and see why the view makes such an impact on those in space.


▲ London by night, from the city to the M25; note that north is at the bottom


▲ Hadfield's rare picture of the Panama Canal, relatively free of clouds


▲ The wild grandeur of the Himalaya mountain range and Earth's horizon


▲ The Caribbean island of Barbados; the capital Bridgetown is at the bottom of the pic


▲ Point Pelee and Pelee Island – forming the southernmost tip of Canada – covered in ice


▲ A Mexican volcano – the streak running from it is an aircraft contrail

IMAGING EARTH

WRITTEN BY IAIN TODD

The photos that ISS astronauts have taken of Earth have the power to inspire and amaze

▲ As this view of the UK and Ireland shows, familiar geographical forms take on a new appearance when seen from orbit and take in Earth's curvature. Photo by Samantha Cristoforetti

▶ These cracks, or wadis, in Yemen's landscape are a geological feature typical of the area, caused by sediment deposition and intermittent water streams. Photo by Samantha Cristoforetti

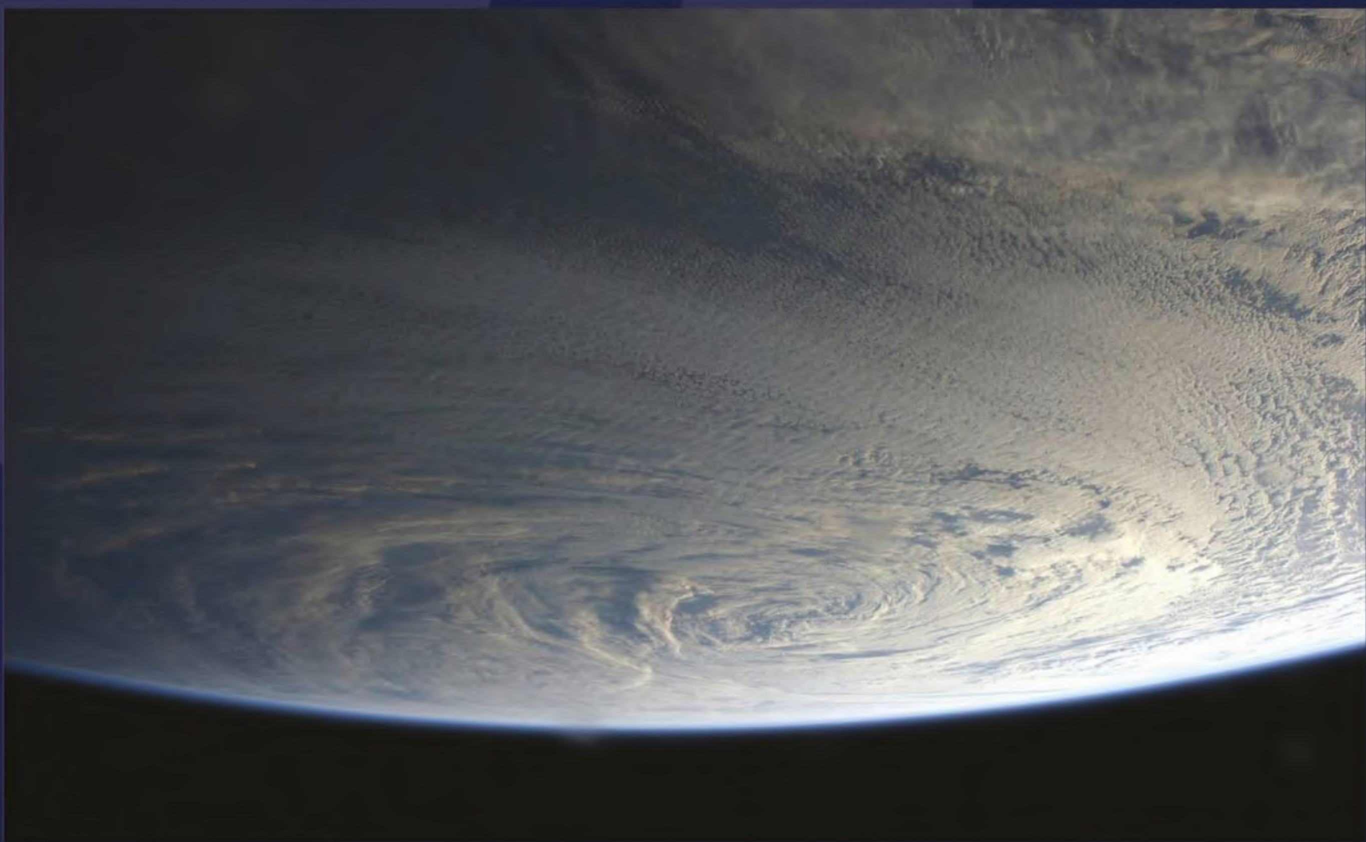
ISTOCK, ESA/NASA X 6

▲ In the arid heat of the north African landscape, the Nile waters in the Aswan Dam stick out as a prominent oasis of life-giving blue. Photo by Alexander Gerst

▲ Lubbock, Texas, is in the largest contiguous cotton growing area in the world. The areas of red dirt are part of the agricultural farmland surrounding the city. Photo by Samantha Cristoforetti

▼ Lightning seen from above is a common nighttime sight from the ISS. From 400km above the Earth, the flash of illumination reveals the structure of the storm cloud. Photo by André Kuipers

▼ A developing storm shrouds the ISS's view of the south Atlantic, north of the Falkland Islands, with long streaks of cloud. Photo by Alexander Gerst



▲ This oblique view off to the distant waning Moon spans the breadth of Earth's atmosphere, from towering tropospheric clouds to the edge of space, where the density of the air gets so low that it no longer scatters blue light. Photo by Jeffrey N Williams

▶ Images such as this aerial view of central London show how large cities dominate their geographical area. Here, the River Thames is the only visible natural feature. Photo by Alexander Gerst

▼ The road from Moscow to St Petersburg: humanity's influence on the planet becomes all the more apparent when darkness falls. Photo by Alexander Gerst

◀ Because astronauts have such a unique perspective of Earth, the pictures they take can often make our planet seem alien. This image of the Grand Canyon in Arizona could easily be a feature on Mars. Photo by Paolo Nespoli

ESA/NASA X 6, NASA

▲ In this image of the Bahamas, lighter blue areas show where the Sun reflects off the sand and reefs of shallow waters. Photo by Samantha Cristoforetti

▼ Humanity's manipulation of nature is evident in images like this, highlighting the effect of agriculture on the Brazilian landscape. Photo by Samantha Cristoforetti

▼ The unique perspective afforded by the ISS enables astronauts to take side-on photos, capturing the depth of phenomena like bright green aurora. Photo by Alexander Gerst

THE SCIENCE OF **IMAGING EARTH**

ESA astronaut Paolo Nespoli gives his perspective on the utility of ISS photography

"The photos we take in space by hand are mostly artistic, but in some cases we are asked to take specific pictures. I remember photographing a city from a side-on position, and you could actually see and measure the depth of the pollution that was covering it. This is something that you can't really see in a picture taken overhead by a satellite. Also, you can pick up certain details by eye that might not be so obvious from a satellite. Then, once you know what you are looking at, the satellite can focus in on the object better than you can with your handheld camera.

There was a case that happened with a crew before me, who noticed a volcano erupting on Earth. Nobody on Earth knew this was happening, but the astronauts were able to pick it up from space. It wasn't dangerous because there were no people living around the volcano, but the ashes could have disrupted airline travel so it was good that the crew discovered it first. I also experienced something similar myself with photos I took of islands in the Pacific. A few months later I found a scientific paper online that had used my pictures, revealing that an island I had photographed was actually an erupting volcano that nobody knew about!

We achieve scientific results with our own photos more by chance, but I think it puts a personal touch on the images when they are taken by people. Observing Earth from this distance helps us remember that the things we do have an effect; things that happen in the UK can change the climate in France, for example, which is something that you don't really think about. Through the eyes of an astronaut, these issues become more apparent to the general public, and I think this does have some sort of influence on the world."

READER OFFER

IMAGE PLUTO

AND OTHER GREAT TARGETS FOR FREE WITH THE BRADFORD ROBOTIC TELESCOPE

By popular demand, *BBC Sky at Night Magazine* has teamed up with the University of Bradford once more to bring you a month's FREE access to its robotic telescope

This exclusive offer gives you free use of the Bradford Robotic Telescope, located in the best observing site in Europe 2,500m above sea level on the island of Tenerife. From this prime location, this fully autonomous observatory will take pictures of the night sky at your request.

Such was the popularity of the offer when we ran it last year in our August 2014 issue, that the facility's state-of-the-art imaging systems will once again be available to you FREE for a month. All you need to do is follow the instructions below to register on the Bradford Robotic Telescope's website.

Once registered, just choose a target from the six listed below and the images will be taken for you automatically while you're sleeping. Log on a few days later and you'll find your images waiting for you. You'll then be able to use the telescope's online image processing tools to get the pictures.

UNIVERSITY of BRADFORD

BBC Sky at Night MAGAZINE

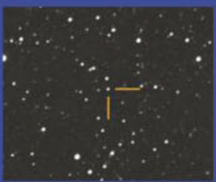
HOW TO GET YOUR MONTH'S FREE ACCESS

1. Go to www.telescope.org
2. Enter the access code PLUTO
3. Try out imaging the six objects below for one month

SEE BELOW FOR DETAILS OF THE TERMS AND CONDITIONS FOR THIS OFFER

IMAGE THESE 6 CELESTIAL WONDERS

PLUTO



As the New Horizons probe arrives at Pluto (marked), take your own observations of this most mysterious dwarf planet. Watch it over days and weeks as it slowly drifts across the sky relative to the stationary stars beyond and see the effect that led to its discovery for yourself.

THE SCULPTOR GALAXY

One of the brighter and larger galaxies in our sky, but often overlooked. View this almost edge-on galaxy in with its highly detailed dust lanes, which are currently in the process of turning into new stars at an unusually high rate.

THE TRIFID NEBULA

This is a spectacular and brightly coloured three-in-one nebula. Your images will show red 'emission' regions of glowing hydrogen gas, blue areas where light is being reflected and scattered from nearby stars, and dark areas of dense dust obscuring what lies behind.

THE PIPE NEBULA

The dark filaments of gas and dust that run through our Galaxy are usually invisible against the black background of space. Only where a dense star field happens to lie behind do we get a chance to see all this dust and gas.

THE PLEIADES

This star cluster has been noticed in the sky by almost every culture since ancient times, but a telescope allows us to see much more. Newly formed stars can be seen blowing away the final remnants of the nebula from which they formed.

THE MOON

Our celestial neighbour is an object that's very familiar to us, but with a telescope far more detail can be seen. This easy target is sure to come out beautifully every time, and with the changing lunar phases each image is different.

Terms and conditions: Promoter is the University of Bradford, Robotic Telescope, School of Engineering & Informatics, University of Bradford, Bradford, BD7 1DP. Entrants must not be employees of the Promoter or Immediate Media Company. Entrants will receive an email confirming registration details immediately after registration. Entrants will have access only to the six objects described above. Entrants may access the offer for one calendar month from date of registration. Access code active until 11.59pm, 1 September 2015. On 1 January 2016 all Free Entrant accounts become regular unpaid accounts, which can be reactivated on payment of the standard fee of £3/month. The Promoter's privacy policy applies, see www.telescope.org./privacy-terms-conditions.php

PLUS

Stephen Tonkin's **BINOCULAR TOUR**

Turn to page 58 for six of this month's best binocular sights

The Sky Guide August

The annual Perseid meteor shower is a highlight of the summer. As well as producing a good number of meteors, some of which can be very bright, it occurs when the nights are still relatively warm. This year, the Moon's out of the way too, leaving the sky nice and dark for a spectacular display.

PETE LAWRENCE

Written by Pete Lawrence

Pete Lawrence is an expert astronomer and astrophotographer with a particular interest in digital imaging. As well as writing *The Sky Guide*, he appears on *The Sky at Night* each month on BBC Four.

Highlights

Your guide to the night sky this month

This icon indicates a good photo opportunity

1 SATURDAY

Noctilucent cloud season comes to an end during the first half of August. See if you can catch a last display 90-120 minutes after sunset, low in the northwest, or a similar time low in the northeast before sunrise.

The Alpha Capricornid meteor shower reaches its peak with a zenithal hourly rate of 10 meteors per hour.

5 WEDNESDAY

Comet 141P/Machholz passes to the north of the Flaming Star Nebula in Auriga tonight and into tomorrow morning. The 11th-magnitude comet is separated from the nebula by around 1° at 01:00 BST (00:00 UT) on 6 August. See page 51.

7 FRIDAY ▶

Comet 141P/Machholz passes less than 1° south of open cluster M38 in Auriga this morning. See page 51.

9 SUNDAY ▶

The Moon and mag. +0.9 Aldebaran (Alpha (α) Tauri) will be less than 1° apart as they rise at 01:00 BST (00:00 UT). The Moon will be a 29%-lit waning crescent.

10 MONDAY

Eleventh-magnitude comet 141P/Machholz passes north of open cluster M37 in Auriga by approximately 1.5° tonight and into tomorrow morning. See page 51.

13 THURSDAY

The Northern Delta Aquariid meteor shower reaches its peak tonight. With a zenithal hourly rate of 20 meteors per hour this is a good shower, but favours those who live further south of the UK.

15 SATURDAY ▶

Venus is at inferior conjunction today, which means it lines up with the Sun on the earthward part of its orbit. After this date the planet will re-emerge in the morning sky. Using care, imagers may be able to follow the planet through inferior conjunction. See page 51.

20 THURSDAY

Mars crosses the Beehive Cluster, M44 in Cancer, this morning and into tomorrow morning. You'll need a very flat northeast horizon for this one as you'll need to catch the passage just as Mars rises, around 04:15 BST (03:15 UT).

22 ◀ SATURDAY

The bright star below and to the right of the first quarter Moon this evening isn't a star at all, but the planet Saturn! They appear to be separated by around 2° at 22:00 BST (21:00 UT), visible low in the southwest part of the sky.

25 TUESDAY

The Northern Iota Aquariid meteor shower peaks tonight with a zenithal hourly rate of eight meteors per hour.

PETE LAWRENCE X 7

6 THURSDAY ▶
Mag. –0.6 Mercury and –1.6 Jupiter will be less than 1° apart very low in the evening twilight after sunset. Look for them in the west-northwest 20 minutes after sunset.

The Southern Iota Aquariid meteor shower reaches its peak with a zenithal hourly rate of eight meteors per hour.

8 SATURDAY
Eleventh-magnitude comet 141P/Machholz lies midway between open clusters M38 and M36 in Auriga at 01:00 BST (00:00 UT) this morning. By 01:00 BST (00:00 UT) on the 9th the comet will have moved further east, but will still be less than 1° from M36.

12 ◀ WEDNESDAY
Tonight is the peak night of the Perseid meteor shower – the actual peak is estimated to occur between 07:30 and 10:00 BST (06:30 and 09:00 UT) on the 13th. The Moon will stay out of the way this year, leading to excellent viewing prospects. See page 50.

16 SUNDAY
A very low pairing of a 4%-lit waxing crescent Moon and mag. –0.1 Mercury may be visible close to the western horizon just after sundown. Try to locate the Moon 15-20 minutes after sunset. A flat western horizon is recommended as the Moon will be very low.

18 TUESDAY
The Kappa Cygnid meteor shower reaches its peak with a zenithal hourly rate of five meteors per hour. Although not the most active of showers, a number of bright fireball events associated with this display have been recorded in previous years.

30 SUNDAY
Mag. –4.2 Venus and +1.8 Mars are 9° apart visible low in the east before sunrise. Venus rises approximately 50 minutes after Mars. Look out for the pair from 05:00 BST (04:00 UT) when both planets will be above the horizon.

31 MONDAY
Eleventh-magnitude comet 141P/Machholz passes very close to mag. +3.6 Kappa (κ) Geminorum. The closest approach of 11 arcminutes occurs at 05:00 BST (04:00 UT), when dawn is underway. Observe from 01:00 BST (00:00 UT) until this time.

What the team will be observing in August

Pete Lawrence "Clouds permitting I'll be out watching the Perseid meteor shower. I've observed this shower since 1977 and the prospect of a moonless display this year is very exciting indeed."

Paul Money "Mars becomes visible in the morning twilight this month and on the mornings of the 20th and 21st it passes through the southern half of the Beehive Cluster, which will be an interesting challenge."

Chris Bramley "I'm focusing on conjunctions. There are lots to see, but I'd be happy to tick off Mercury and Jupiter on the 6th, and Saturn and the Moon on the 22nd."

Need to know

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object lies on the celestial 'globe'.

HOW TO TELL WHAT EQUIPMENT YOU'LL NEED

NAKED EYE
Allow 20 minutes for your eyes to become dark-adapted

BINOCULARS
10x50 recommended

PHOTO OPPORTUNITY
Use a CCD, planetary camera or standard DSLR

SMALL/MEDIUM SCOPE
Reflector/SCT under 6 inches, refractor under 4 inches

LARGE SCOPE
Reflector/SCT over 6 inches, refractor over 4 inches

Getting started in astronomy

If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing your first scope.

DON'T MISS...

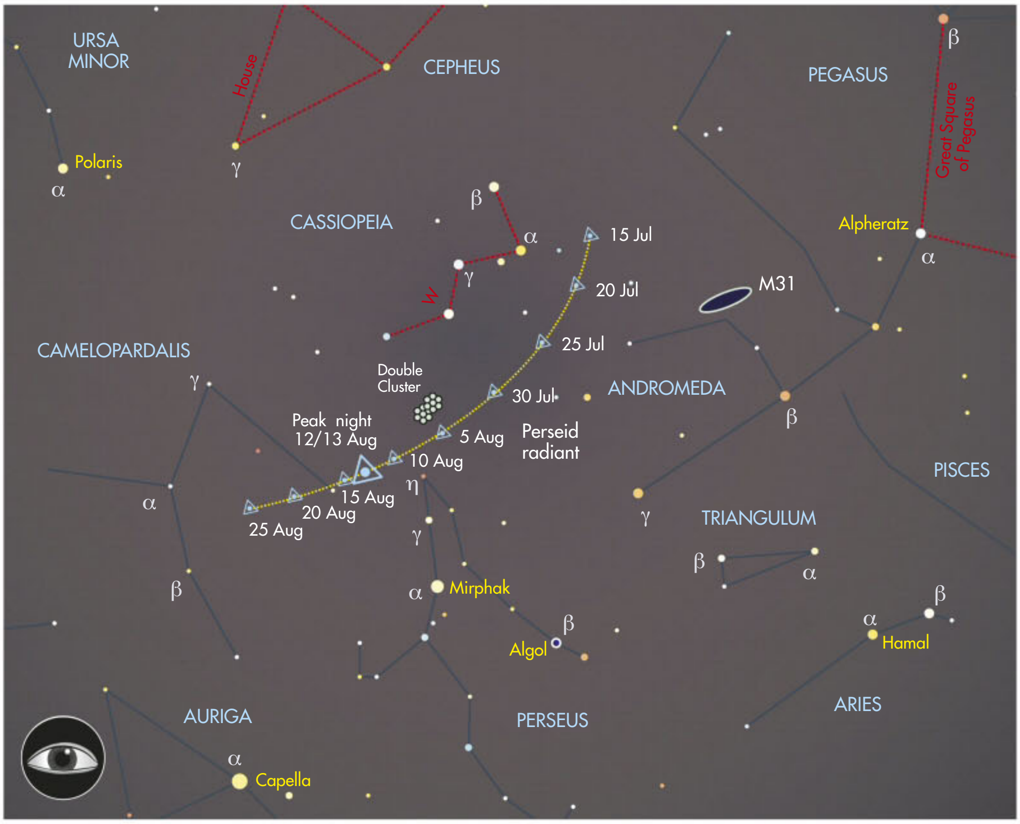
3 top sights

The Perseids 2015

WHEN: 7-18 August; peak on 12/13 August

NEED TO KNOW

The zenithal hourly rate of a meteor shower is the expected number of meteors seen under perfect conditions with the radiant point of the shower overhead.



The Perseid radiant drifts across the sky through mid July and August; at the peak it will be near Eta Persei

THE PERSEID METEOR shower returns this month and with the Moon being out of the way for the peak period, this year's display has the potential for being a good one. The Perseids are one of the more reliable of the annual showers due to their high zenithal hourly rate (ZHR) of between 80-100 meteors per hour and good UK visibility. Also, the warm nights of August make for comfortable viewing conditions, another factor that makes the Perseids popular.

The shower is active for about a month, with trails appearing from about 23 July through to 23 August. There are other showers active at this time of year too, so just because you see a meteor, this is not a guarantee that it's a Perseid. Turn to page 60 for tips on how to identify a true Perseid.

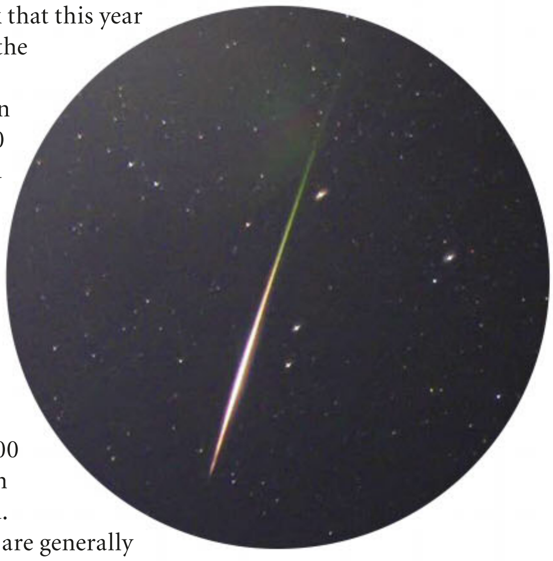
During this period, the radiant position slowly drifts across the sky. If you imagine the W of Cassiopeia the right way up, it starts just below the W's right edge. It then slips east into Perseus, with its peak occurring a little to the east of mag. +3.8 star Eta (η) Persei. After this the radiant continues to drift east, eventually petering out in the constellation of Camelopardalis.

Perseid activity is typically low throughout much of the shower's life, with ZHR rates of 5-10 meteors per hour. They start to increase around the night of 7/8 August, building to a sharp peak that this year occurs during the morning of 13 August between 07:30 and 10:00 BST (06:30 and 09:00 UT). This will be daylight for the UK, but rates on the night of the 12/13th from around 23:00 BST (22:00 UT) until dawn should be good.

Perseid rates are generally at their best after 01:00 BST (00:00 UT) when the Earth turns to encounter the meteoroids head on. This raises trail brightness, so more are seen. After the peak, rates take a sharp decline, reaching their low 5-10 per hour value around 18 August. Even when the rates are low there's always a chance of spotting a bright Perseid fireball, so it's worth keeping a look out all month.

The best way to observe the Perseids visually is from a good dark spot away from stray lights. Let your eyes adjust to the dark for about 20 minutes and then start your watch. Observing from 23:00 BST through to around 03:15 BST (22:00 to 02:15 UT) on the night of the 12/13th should let you see the best activity.

Look up to a height of around 60°. Any direction will do, but we'd recommend a view towards the Summer Triangle asterism at the start of the session, moving around to the east for the pre-dawn watch.



▲ **Your best chance of spotting a Perseid is on the night of the peak**

PETE LAWRENCE X4

Comet 141P/Machholz passes through Auriga

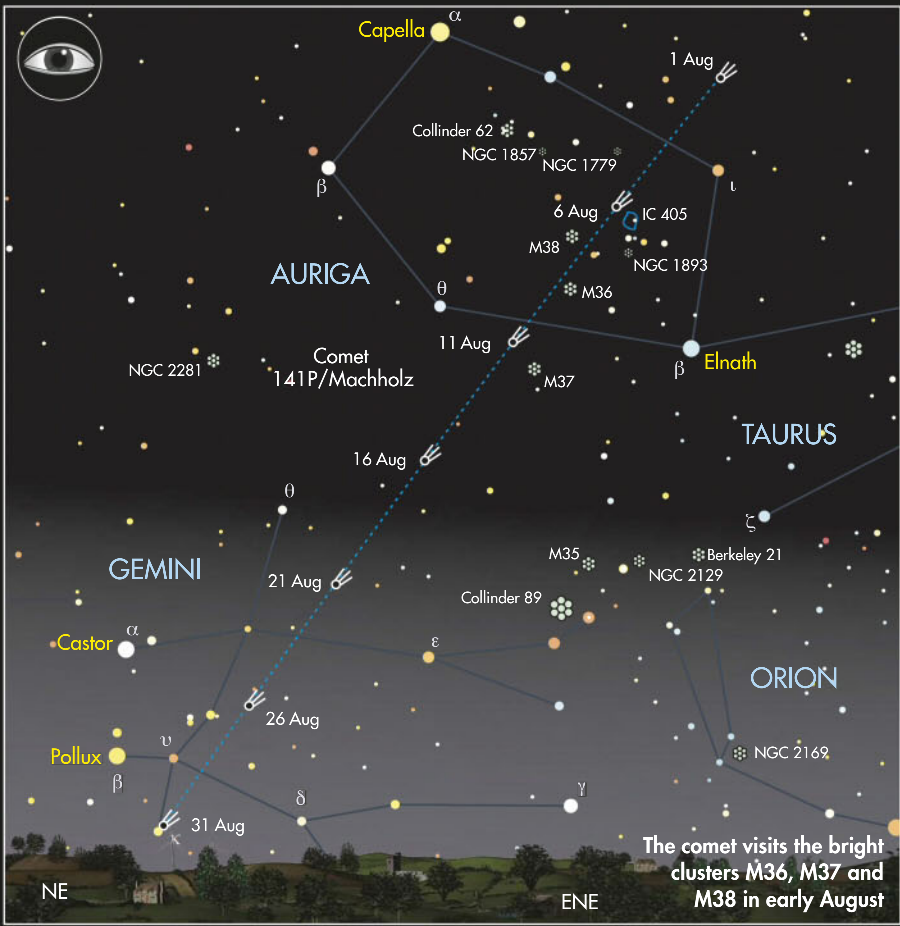
WHEN: 5-11 August

COMET 141P/MACHHOLZ begins August in Perseus but quickly hops across the border into Auriga, where it then spends a good deal of the month passing some beautiful background deep-sky objects. On 1 August it should be around 11th magnitude, which means it'll be on the edge of visibility for a small telescope, but a fairly easy spot for larger scopes.

By midnight on the 5th the comet should have brightened very slightly and will be positioned to the north of the Flaming Star Nebula, IC 405. The red emission of the nebula should contrast nicely with the greenish coma of the comet.

On the nights of 6/7 and 7/8 August, 141P/Machholz will pass just to the south of the lovely mag. +6.4 open cluster M38. The comet's travels take it less than 1° from the cluster. At midnight on the 7th the comet is located midway between M38 and a slightly brighter open cluster, mag. +6.0 M36. It should be around mag. +11.4 at this time. The following night on 8/9 August, it lies less than 1° northeast of M36. M37 is the brightest of the M36, M37, M38 trio in Auriga and Machholz pays it a visit too. On the night of 10/11 August, the comet will be 1.3° north of M37.

We'd recommend waiting until 02:30-03:00 BST (01:30-02:00 UT) to view the comet, when it will have gained some altitude and be 25° up, low in the east-northeast. 141P/Machholz is a complex object known to have fragmented in the past. It's worth noting that its brightness can be somewhat unpredictable.



The comet visits the bright clusters M36, M37 and M38 in early August

Venus at inferior conjunction

WHEN: 10-20 August

Venus's crescent appears to swivel as its inferior conjunction progresses and the planet moves past the Sun

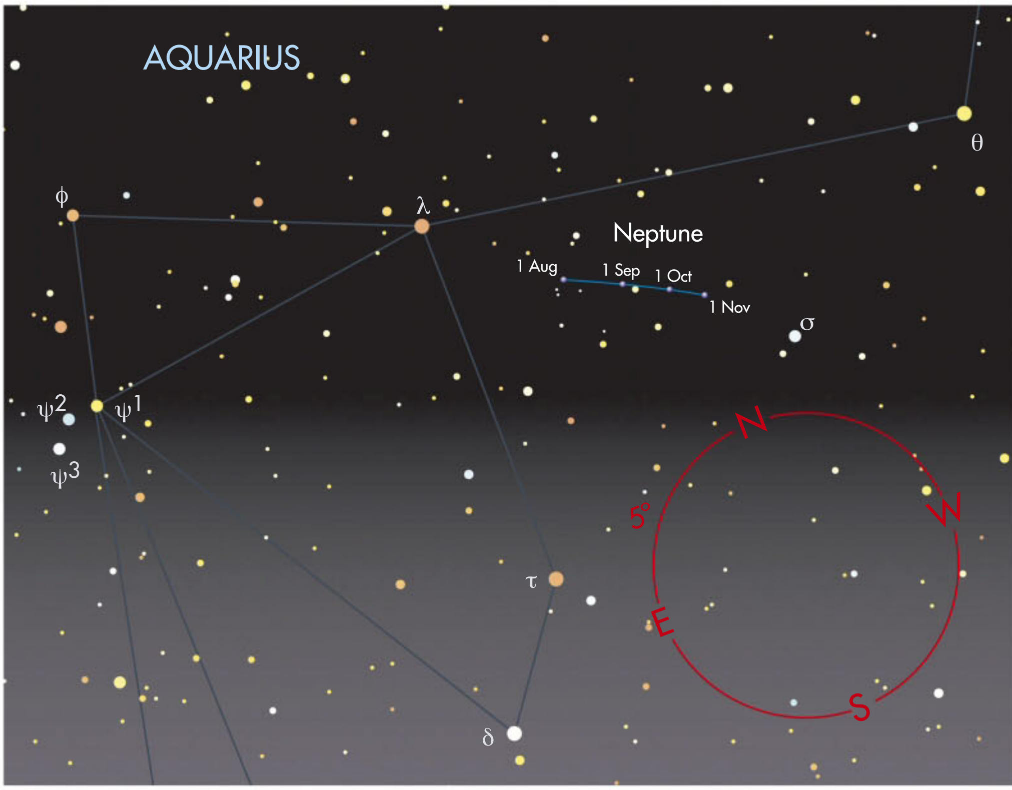
THE BRILLIANT PLANET Venus lines up with the Sun on 15 August, when it reaches a position in its orbit known as inferior conjunction. This is when it's on the earthward side of its orbit, between us and the Sun. In contrast, superior conjunction occurs when it lines up with the Sun on the most distant part of its orbit.

The line-up is not precise and Venus will pass south of the Sun's disc. This time round the distance is respectable, with the star and planet being separated by around 8°. This means that with care, it's possible to image the crescent of Venus as it passes through inferior conjunction. The line from the centre of the planet's disc, through the thickest part of the crescent, always points to the Sun. Consequently it appears to swivel as Venus passes into the morning sky.

The crescent is very thin and great care is required to catch it with a camera. We covered how to locate Venus by using the Sun in the *Sky Guide* last month – you can read an abridged version of this article online at **www.skyatnightmagazine.com/feature/how-guide/how-find-image-venus**. This is not a safe visual target so it's cameras only we're afraid.

The planets

PICK OF THE MONTH



Neptune is gradually edging towards Sigma Aquarii; its huge orbit means that its progress is slow

NEPTUNE

BEST TIME TO SEE:
31 August 01:00 BST (00:00 UT)
ALTITUDE: 28°
LOCATION: Aquarius
DIRECTION: South
RECOMMENDED EQUIPMENT:
8-inch or larger telescope
FEATURES OF INTEREST:
Colour, moon Triton with larger scopes

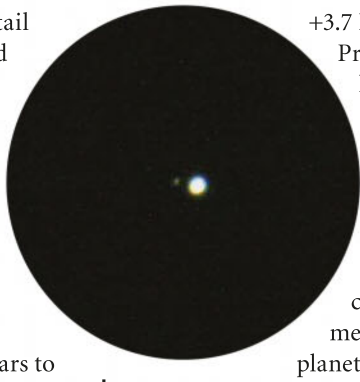
WITH THE DEMOTION of Pluto to the status of dwarf planet in 2006, Neptune became the Solar System's outermost planet. It orbits with an average distance of 30 AU – that's 30 times the Earth-Sun distance, or about 4.5 billion km.

It's a sizeable world, having a diameter 3.9 times that of Earth, nearly 50,000km across. However, at such a large distance away, even this size renders the planet as little more than a dot though an average amateur telescope. Actually, this does Neptune a bit of a disservice as the dot is obviously non-stellar in a 3-inch telescope at magnifications of around 150x. The disc becomes more obvious at higher powers but the planet doesn't give much away in terms of detail. The most obvious thing about a telescopic view of Neptune is the planet's blue colouration, caused by its atmosphere being good at absorbing the longer wavelengths.

Consequently, most detail will be seen in the red and infrared part of the spectrum. Imagers with 10-inch or larger scopes using a mono camera with a red or infrared filter stand the best chance of picking up bright spots or banding on the disc.

Neptune takes 164.8 years to complete one orbit around the Sun, which means that its apparent movement against the background stars is slow. It's currently in Aquarius, about 3° southwest of mag. +3.7 Lambda (λ) Aquarii. Probably the best way to locate the planet is to first find this star, then mag. +4.8 Sigma (σ) Aquarii. Neptune sits on the mid-point of a line between the two stars.

Neptune tends to hover close to mag. +8.0, which means that it's the only planet in the sky that requires optical assistance to see, in theory at least. At mag. +5.8, the planet Uranus is possible to see with the naked eye, but tricky to spot with any light pollution present.

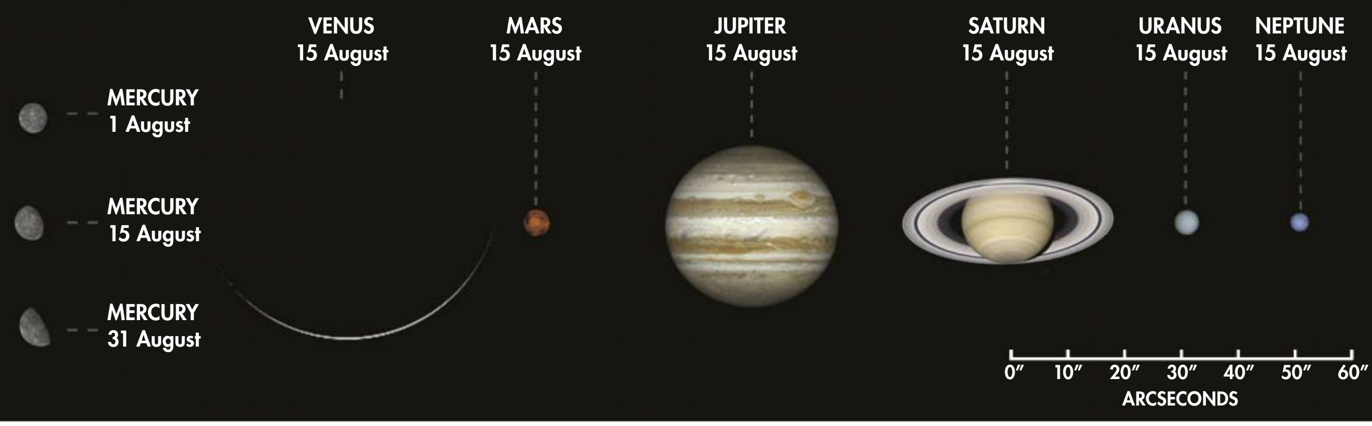


Larger scopes can reveal Triton as well as Neptune itself

PETE LAWRENCE X 3

THE PLANETS IN AUGUST

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



VENUS

BEST TIME TO SEE: 31 August 05:30 BST (04:30 UT)
ALTITUDE: 6° (low)
LOCATION: Cancer
DIRECTION: East

Venus is at inferior conjunction on 15 August, when it lines up with the Sun on the earthward side of its orbit. This marks the planet's transition from an evening to a morning object. Your best chance of spotting Venus will be in the morning sky towards the end of August. On the 24th Venus rises 40 minutes before the Sun, but by the 31st this will have increased to one hour and 40 minutes.

URANUS

BEST TIME TO SEE: 31 August 03:30 BST (02:30 UT)
ALTITUDE: 44°
LOCATION: Pisces
DIRECTION: South

Uranus's position continues to improve, the planet reaching its highest point in the sky, due south, at the end of the month. On the 27th, mag. +5.7 Uranus is in line with mag. +5.2 Zeta (ζ) and mag. +6.0 88 Piscium. The planet is three-quarters of the way along the line from the former to the latter.

SATURN

BEST TIME TO SEE: 1 August 22:00 BST (21:00 UT)
ALTITUDE: 16°
LOCATION: Libra
DIRECTION: South-southwest

Saturn is now past its best for the year, appearing low in the southwest as the sky darkens. It's still worth trying to get a view of the planet through a telescope as the rings are now wide open and quite beautiful. The first quarter Moon is 2° northeast of the planet at 21:30 BST (20:30 UT) on the 22nd; look low in the southwest.

MARS

BEST TIME TO SEE: 31 August 05:30 BST (04:30 UT)
ALTITUDE: 12° (low)
LOCATION: Cancer
DIRECTION: East

Mars is a morning planet, rising 80 minutes before the Sun at the start of August and 140 minutes by month end. It's around mag. +1.7 and a bit of a disappointment telescopically due to its tiny 3.7-arcsecond disc. On the 12th, a 5%-lit crescent Moon sits 12° to its right, low in the east-northeast at 04:30 BST (03:30 UT). Mars crosses the Beehive Cluster, M44, on the mornings of 20-21 August, but it will be a tricky spot because the dawn twilight will brighten as they gain altitude. Try just after Mars rises, about 04:00 BST (03:00 UT) low in the northeast.

MERCURY

BEST TIME TO SEE: 6 August 21:00 BST (20:00 UT)
ALTITUDE: 3° (low)
LOCATION: Leo
DIRECTION: West-northwest

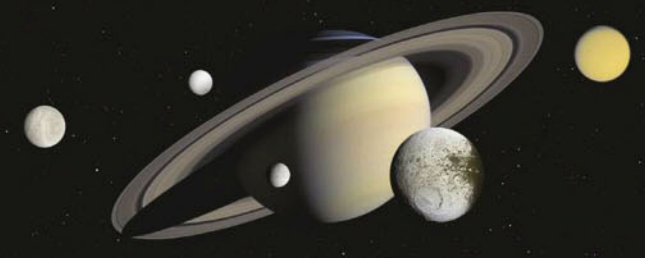
Mercury isn't well positioned this month, being located in the evening sky, and is best seen after sunset at the start of August. On the 6th and 7th, mag. –0.6 Mercury is located close to mag. –1.6 Jupiter. The pair, separated by less than 1° on both evenings, may be seen 20 minutes or so after sunset, very low in the west-northwest. On 7 August, the two planets form an almost equilateral triangle with mag. +1.4 Regulus (Alpha (α) Leonis). A 5%-lit crescent Moon lies slightly less than 4° below and left of Mercury on 16 August.

JUPITER

BEST TIME TO SEE: 6 August 21:00 BST (20:00 UT)
ALTITUDE: 3° (low)
LOCATION: Leo
DIRECTION: West-northwest

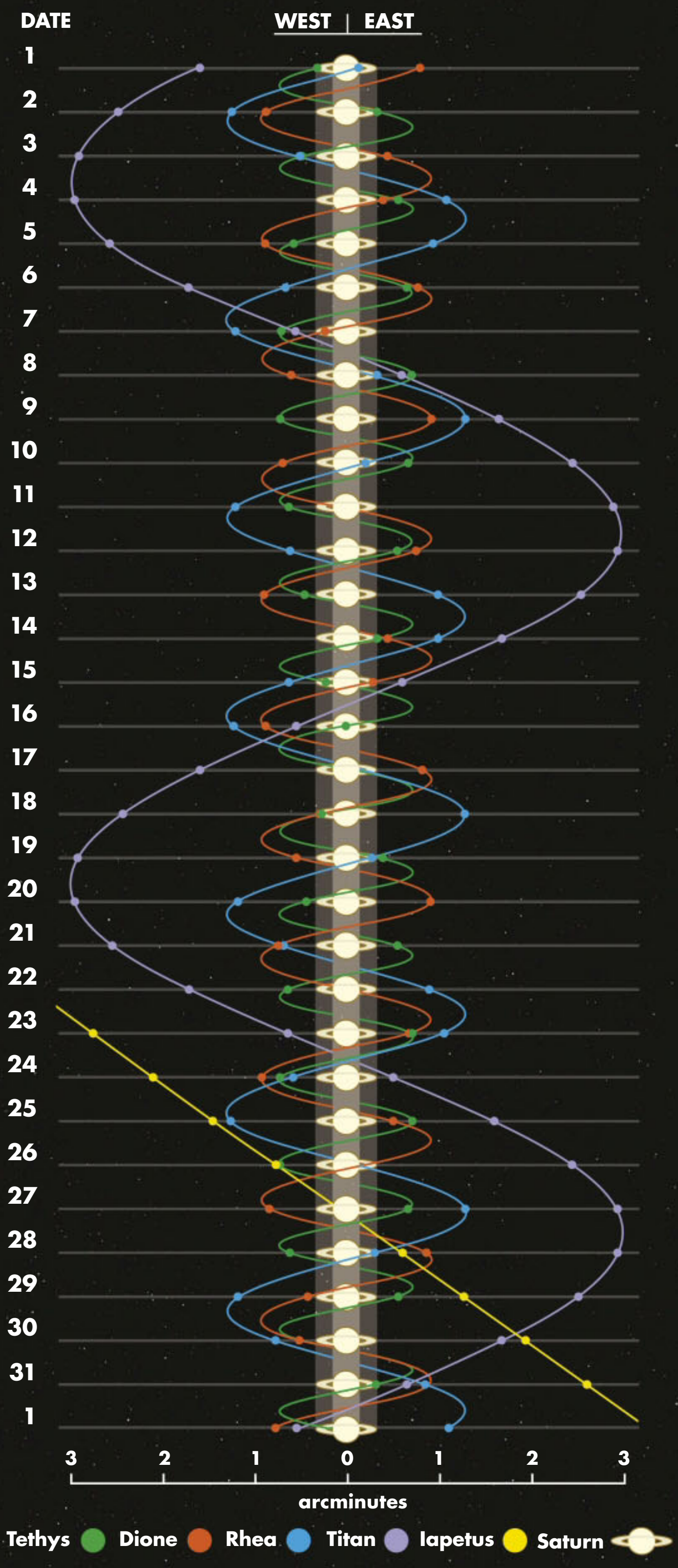
Jupiter is now too close to the Sun for serious observation, reaching solar conjunction on 27 August. The planet has a close encounter with mag. –0.6 Mercury on the 6th and 7th, and passes 26 arcminutes north of Regulus on the 10th.

See what the planets look like through your telescope with the **field of view calculator** on our website at:
http://www.skyatnightmagazine.com/astronomy-tools



SATURN'S MOONS August

Using a small scope you'll be able to spot Saturn's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date on the left represents 00:00 UT.



The Northern Hemisphere

KEY TO STAR CHARTS

Arcturus	STAR NAME
PERSEUS	CONSTELLATION NAME
	GALAXY
	OPEN CLUSTER
	GLOBULAR CLUSTER
	PLANETARY NEBULA
	DIFFUSE NEBULOSITY
	DOUBLE STAR
	VARIABLE STAR
	THE MOON, SHOWING PHASE
	COMET TRACK
	ASTEROID TRACK
	STAR-HOPPING PATH
	METEOR RADIANT
Circlet	ASTERISM
	PLANET
	QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

COMPASS AND FIELD OF VIEW

MILKY WAY

WHEN TO USE THIS CHART

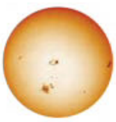
1 AUGUST AT 01:00 BST
15 AUGUST AT 00:00 BST
31 AUGUST AT 23:00 BST

On other dates, stars will be in slightly different places due to Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART

1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.

THE SUN IN AUGUST*



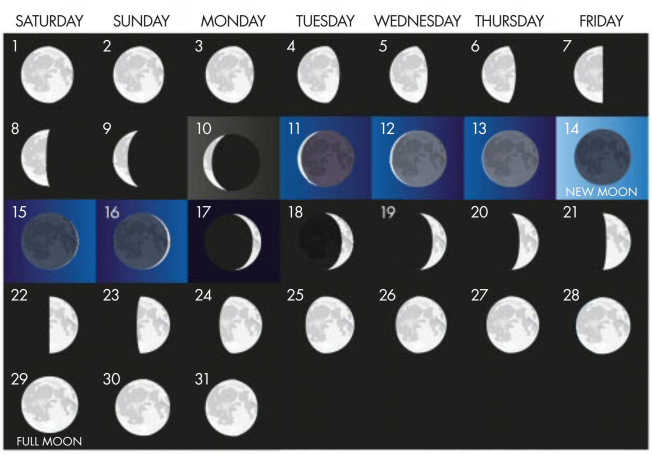
DATE	SUNRISE	SUNSET
1 Aug 2015	05:25 BST	21:06 BST
11 Aug 2015	05:42 BST	20:46 BST
21 Aug 2015	05:59 BST	20:25 BST
31 Aug 2015	06:17 BST	20:02 BST

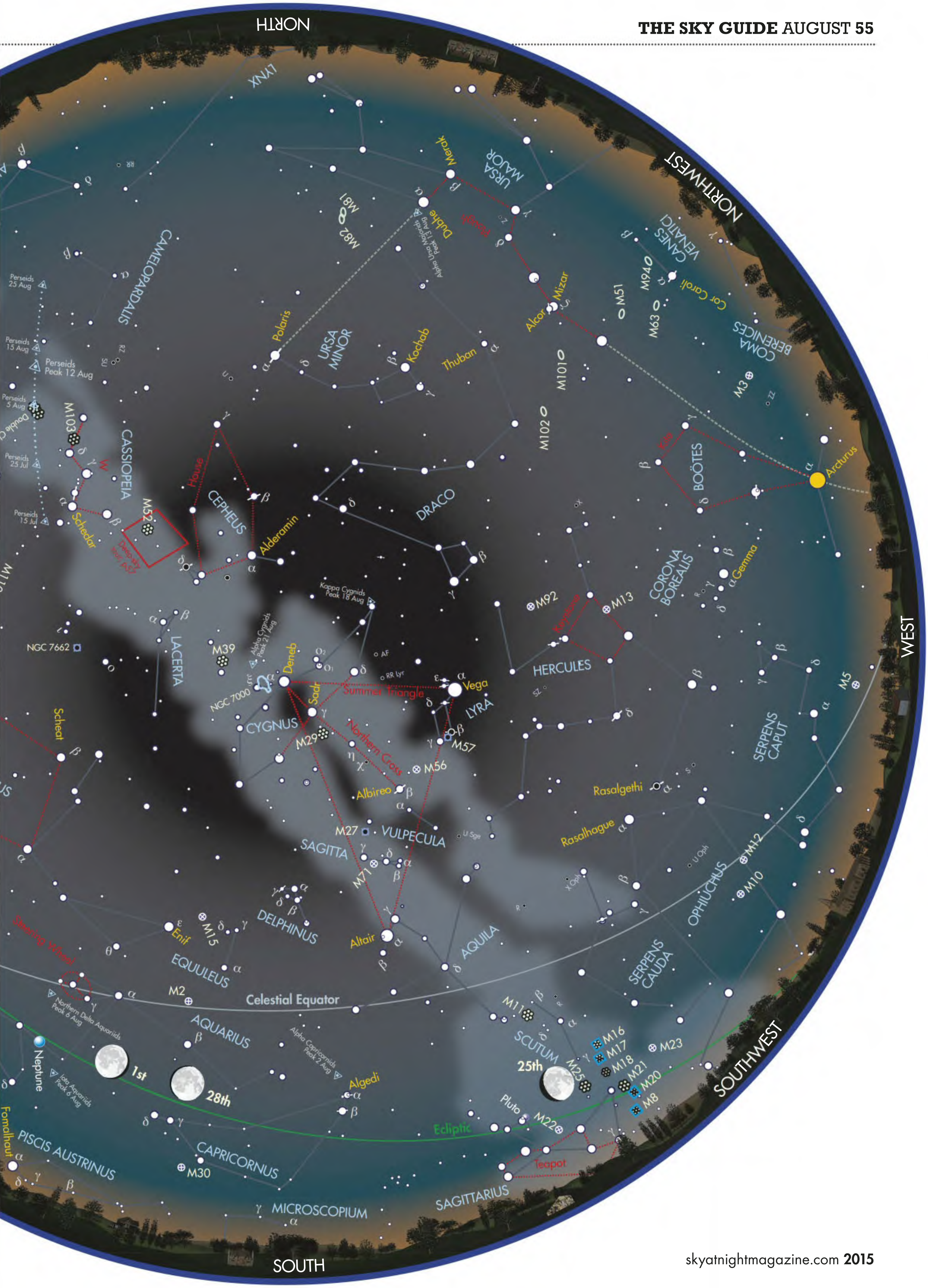
THE MOON IN AUGUST*

MOONRISE TIMES

1 Aug 2015, 21:20 BST	17 Aug 2015, 08:55 BST
5 Aug 2015, 23:14 BST	21 Aug 2015, 13:10 BST
9 Aug 2015, 01:00 BST	25 Aug 2015, 17:08 BST
13 Aug 2015, 04:39 BST	29 Aug 2015, 19:48 BST

*Times correct for the centre of the UK

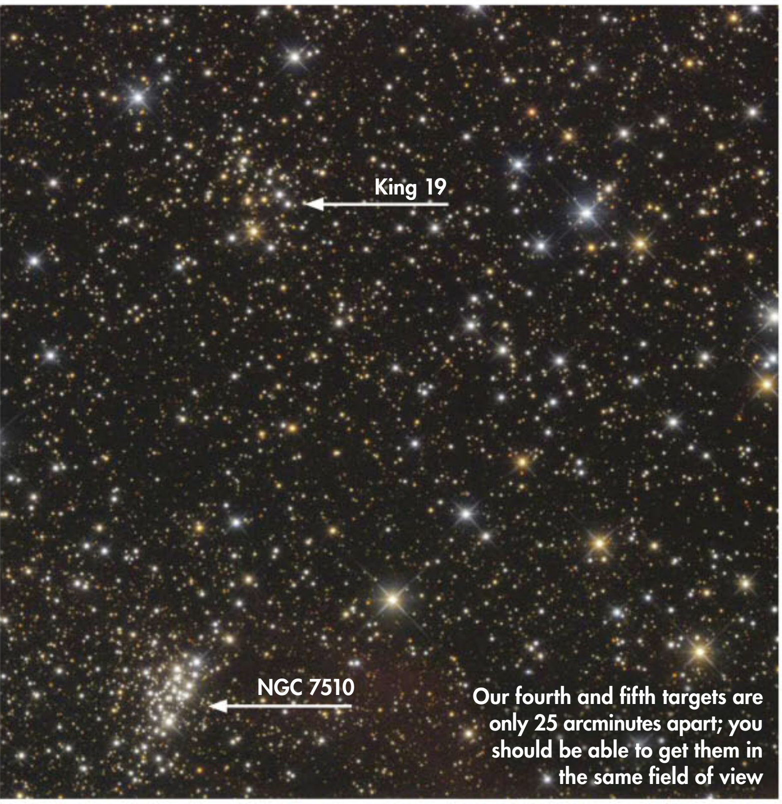



NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
LYNX
URSA MAJOR
Merak
Dubhe
Plough
M81
M82
Alpha Ursa Majorids Peak 15 Aug
CANES VENATICI
Cor Caroli
M94
M63
M51
Mizar
Alcor
COMA BERENICES
M3
CAMELOPARDALIS
Polaris
URSA MINOR
Kochab
Thuban
M101
M102
Perseids 25 Aug
Perseids 15 Aug
Perseids Peak 12 Aug
Perseids 5 Aug
Perseids 25 Jul
Perseids 15 Jul
M103
CASSIOPEIA
W
House
CEPHEUS
Kite
BOÖTES
Arcturus
DRACO
Alderamin
Schedar
M52
Deep-sky tour AS7
CORONA BOREALIS
Gemma
Kappa Cygnids Peak 18 Aug
M92
Keystone
M13
HERCULES
NGC 7662
LACERTA
M39
Alpha Cygnids Peak 21 Aug
Deneb
Sadr
Summer Triangle
Vega
LYRA
NGC 7000
CYGNUS
M29
Northern Cross
M57
M56
Scheat
SERPENS CAPUT
M5
Albireo
Rasalgethi
Rasalhague
M27
VULPECULA
SAGITTA
M71
OPHIUCHUS
M12
M10
DELPHINUS
Altair
AQUILA
Enif
M15
Steering Wheel
EQUULEUS
M2
Celestial Equator
SERPENS CAUDA
Northern Delta Aquariids Peak 6 Aug
AQUARIUS
Alpha Capricornids Peak 2 Aug
M11
SCUTUM
M16
M17
M18
M23
M21
M20
M8
M25
25th
Nepture
1st
28th
Iota Aquariids Peak 6 Aug
Algedi
Pluto
M22
Ecliptic
Fomalhaut
PISCIS AUSTRINUS
CAPRICORNUS
M30
Teapot
SAGITTARIUS
MICROSCOPIUM

Deep-sky tour

August's skies offer a string of open clusters and nebulae hiding in Cassiopeia and Cepheus

☑ Tick the box when you've seen each one



Our fourth and fifth targets are only 25 arcminutes apart; you should be able to get them in the same field of view

1 M52

Eighth-magnitude open cluster M52 is easily within reach of a small scope, and easily found too. Extend an imaginary line from mag. +2.2 Schedar to mag. +2.3 Caph (Alpha (α) through Beta (β) Cassiopeiae; neither shown on chart) and continue for the same distance again. Orange mag. +5.0 star 4 Cassiopeia lies 40 arcminutes to the north. The cluster's brightest member is a mag. +7.7 yellow giant star. A 4-inch scope at 30x magnification shows M52 as a misty oval; approximately 10 stars appear at 60x. A 6-inch scope increases the count to around 50 stars. M52 is believed to be 35 million years old but its distance is uncertain due to intervening Milky Way dust. Current estimates put it at between 3,000 and 7,000 lightyears away. ☐ **SEEN IT**

2 THE BUBBLE NEBULA

The Bubble Nebula, NGC 7635, gets its name because it contains an oval bubble feature blown in nebula material by the young mag. +8.7 star SAO 20575. This star is estimated to be 44 times as massive as our Sun and 398,000 times as luminous. The bubble is actually a sphere of material, but only the foreshortened edges of the sphere appear distinct. The nebula lies 0.5° to the southwest of M52 and can be seen with a 10-inch scope (or a 8-inch scope under good conditions) as a faint ring. The nearby mag. +6.9 star TYC 4279-702-1 is a nuisance because it dazzles the eye. ☐ **SEEN IT**

3 MARKARIAN 50

Markarian 50 is a mag. +8.5 open cluster located on the border between Cassiopeia and Cepheus. It lies just under 1° southwest of the Bubble Nebula and contrasts with M52 because it is rather tiny, measuring just 2 arcminutes across. A low magnification of around 50x will show its cluster form, but higher powers are required to discern the arc of around a dozen stars that give Markarian 50 its characteristic shape. A 10-inch scope at around 350x shows the cluster extremely well and really brings out the arc. The brightest star in the cluster appears red-orange in colour. ☐ **SEEN IT**

4 NGC 7510

We slip slightly over the border from Cassiopeia into Cepheus to get to our next target, open cluster NGC 7510, which lies 0.5° west of Markarian 50. This is a pretty cluster, slightly brighter than Markarian 50 at mag. +7.9 and a bit larger at 5 arcminutes in length. It stands out well against the background stars and looks somewhat flattened into a pattern that resembles the head of an arrow. It gets this appearance thanks to two approximately parallel lines of faint stars. The brightest star in the cluster has a magnitude of +9.6. ☐ **SEEN IT**

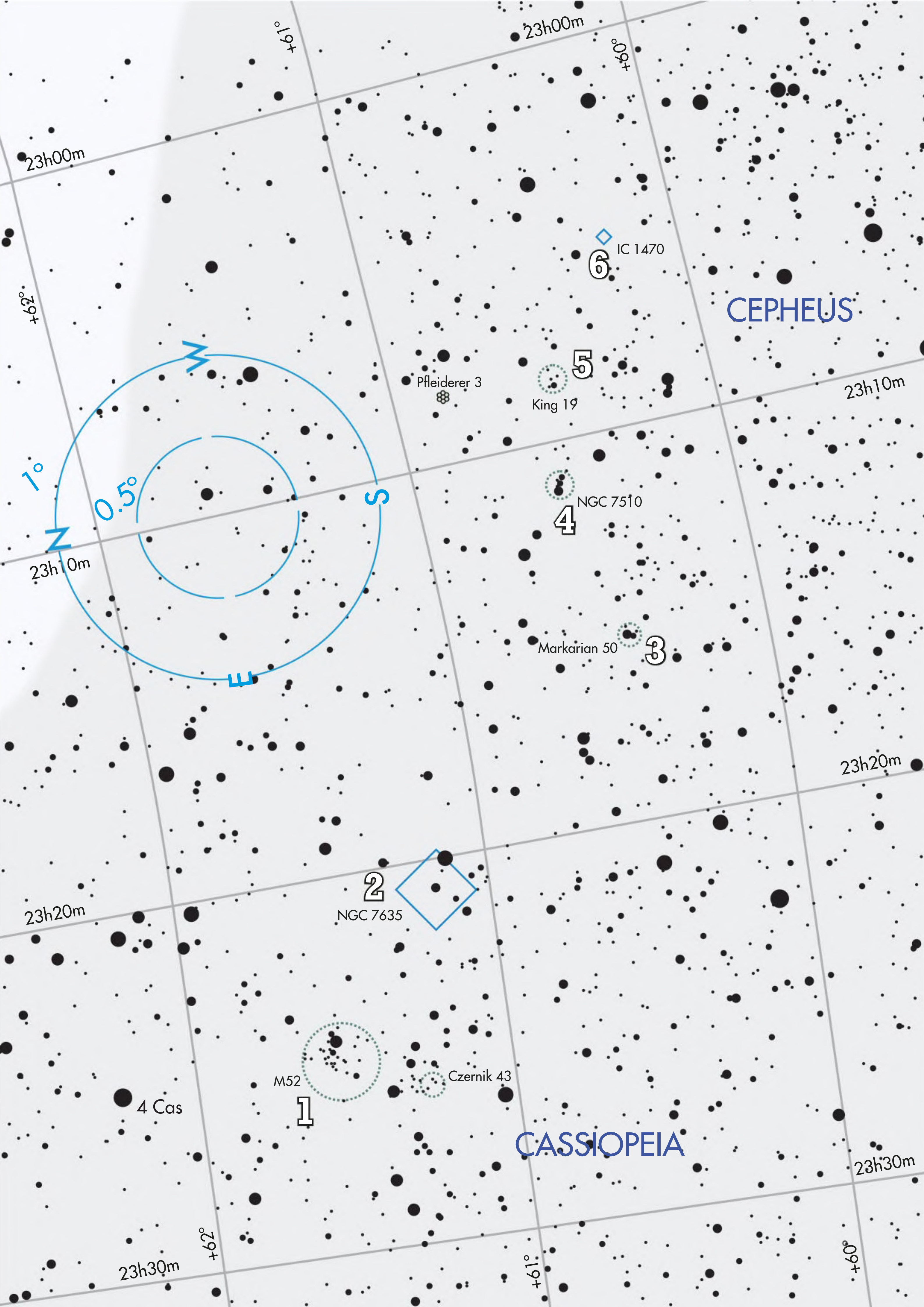
5 KING 19

Located approximately 25 arcminutes to the west of NGC 7510 is the slightly smaller and dimmer open cluster known as King 19. In an 8-inch scope you should be able to see around 15 stars ranging in brightness from 11th to 13th magnitude. Being so close to NGC 7510, it's an interesting exercise to put both into the same field of view and compare the two. King 19 appears much less populated than the wedge-shaped NGC 7510, barely standing out against the background sky. With dark skies and averted vision it may be possible to make out that the cluster has a slight east-west elongation. ☐ **SEEN IT**

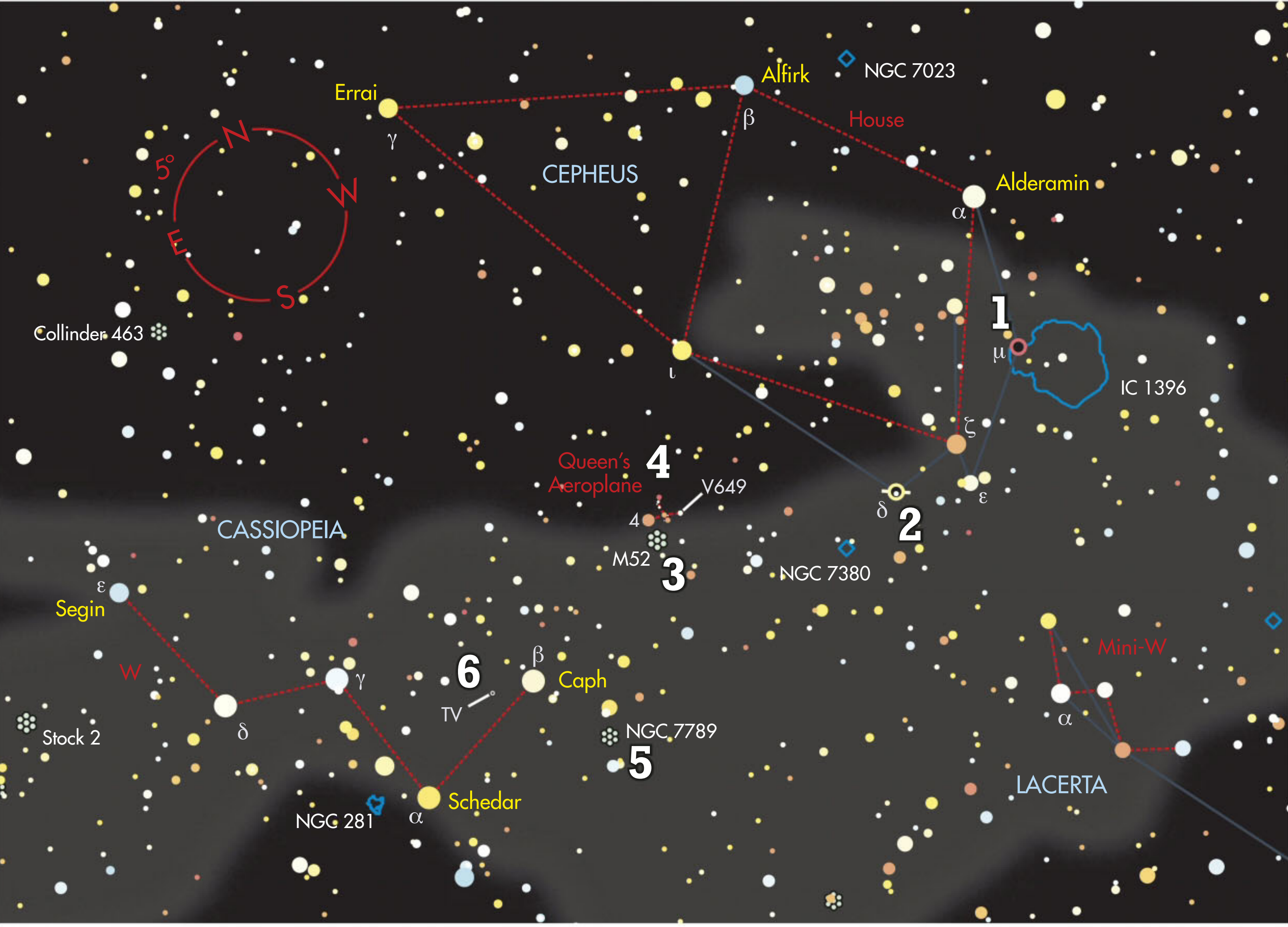
6 IC 1470

Our last target is a patch of HII emission nebulosity known as IC 1470 (Sh2-156). This is located by continuing the southwest target progression we've been following: it lies slightly farther from King 19 as the distance between King 19 and NGC 7510. The nebula is small, visually measuring just over 1 arcminute across. With a low magnification it looks like a fuzzy star in appearance. At mag. +11.5, you'll need a 10-inch or larger scope to make out any detail. A challenge for larger apertures is to look for the nebula's triangular core, which is divided by darker material. A 13th-magnitude star sits within the nebula. ☐ **SEEN IT**

CHART: PETE LAWRENCE, PHOTO: KERSCHHUBER GÜNTER/ASTRONOMER ARBEITSKREIS SALZKAMMERGUT



23h00m
+61°
23h00m
+60°
+62°
IC 1470
6
CEPHEUS
1°
0.5°
N
W
S
E
Pfleiderer 3
5
King 19
23h10m
23h10m
NGC 7510
4
Markarian 50
3
23h20m
23h20m
2
NGC 7635
M52
1
Czernik 43
4 Cas
CASSIOPEIA
23h30m
23h30m
+62°
+61°
+60°



With
Stephen Tonkin

Binocular tour

August brings a jewel, a flower and a scientifically significant double

☑ Tick the box when you've seen each one

1 HERSCHEL'S GARNET STAR

10x 50 Just a little southwest of the mid-point of a line between mag. +2.5 Alderamin (Alpha (α) Cephei) and mag. +3.4 Zeta (ζ) Cephei is mag. +4.0 Mu (μ) Cephei, named for William Herschel, whose description is as appropriate today as it was when it was written in 1783: "of a very fine deep garnet colour and … a most beautiful object, especially if we look for some time at a white star before we turn … to it, such as Alpha Cephei, which is near at hand." Jupiter would orbit inside this huge red supergiant, which is one of the largest known stars. ☐ **SEEN IT**

2 DELTA CEPHEI

10x 50 Variable star Delta (δ) Cephei (mag. +3.6 to +4.5, period 5.37 days) gave its name to an entire class of variable stars for which Henrietta Leavitt demonstrated the relationship between the period of variation and luminosity. This relationship allowed them to be used as the first 'standard candle' for measuring the size of the Universe. This star is not only here for that reason, though: it is a beautiful binocular double with a deep yellow primary star and a brilliant white 6th-magnitude secondary. ☐ **SEEN IT**

3 M52

10x 50 Mag. +6.9 open cluster M52 rests on a straight line extended from mag. +2.2 Schedar through mag. +2.3 Caph (Alpha (α) and Beta (β) Cassiopeiae), 6° northwest of Caph. In 10×50 binoculars, M52 appears as a grainy glow in the form of an arrowhead that is 13 arcminutes long and well differentiated from the Milky Way stars. There is a brighter (mag. +8.3) star on the western side, which will probably be the only one of the nearly 1,000 cluster stars that you can resolve. ☐ **SEEN IT**

4 THE QUEEN'S AEROPLANE

10x 50 Just under 1° north of M52 lies the golden yellow mag +5.0 4 Cassiopeiae, which marks the starboard wingtip of our next object, a pretty aeroplane-shaped asterism in which eight stars are mag. +8.0 or brighter, making it fairly easy to identify, even in poor skies. The other wingtip, 1° to the west, is the mag. +6.6 blue-white star, V649 Cassiopeiae. The 'fuselage' extends nearly 1° to the north as far as a mag. +6.7 orange-red star. You will need to have dark and transparent skies to enable you to appreciate the variety of colours on display. ☐ **SEEN IT**

5 CAROLINE'S ROSE

15x 70 Our next object is another 1783 Herschel discovery, but this time by William's sister, Caroline. Open cluster NGC 7789, also known as Caroline's Rose, sits 6° west of Schedar, forming a triangle with Caph at the right-angled apex. In 15x70 binoculars it appears as a soft glow spanning about half the apparent diameter of the Moon; even if you use averted vision, you are unlikely to be able to tease out any individual stars. With an age of about a billion years, Caroline's Rose is unusually old for an open cluster and imagery shows that most of its stars have become red giants. ☐ **SEEN IT**

6 TV CASSIOPEIAE

15x 70 You really need 15x70 binoculars at least to appreciate the variability of our last object, which is 0.25° east of Caph and normally shines at mag. +7.2. TV Cassiopeiae is an Algol-type eclipsing binary star with a period of 1.81 days, when it dims by one magnitude and rises again to its normal brightness during the nine-hour eclipse. Because the eclipses are four and a half hours earlier on successive days, it is relatively easy to observe them every week or so at a convenient time. ☐ **SEEN IT**

CHARTS AND PICTURES: PETE LAWRENCE

Moonwatch

Sulpicius Gallus

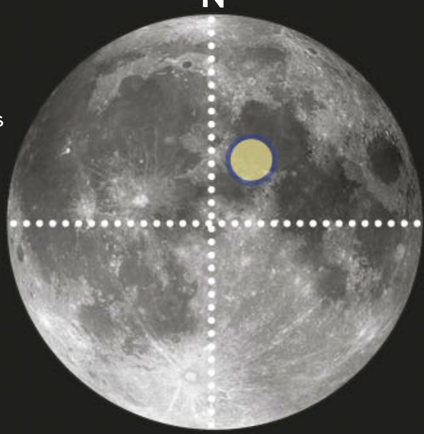
SULPICIUS GALLUS IS a small, bowl-shaped crater close to the southwest border of the Mare Serenitatis. Despite its diminutive size, Sulpicius Gallus is quite prominent: it is bright and has a rim that rises above the surrounding floor of the lunar sea. Consequently, when the Sun is high in the lunar sky, the crater looks like a bright patch against the darker mare floor. When the Sun is low in the lunar dawn sky, Sulpicius Gallus casts a dramatic shadow across the mare which, at high magnification, shows the rim has somewhat jagged edges.

The closest part of the border of the Mare Serenitatis lies about 20km to the southwest of the crater. The mare boundary is marked by the curving mountain range Montes Haemus. This arcs along the southwest edge of Serenitatis, starting in the east to the north of crater Plinius (43km). The range curves up to the western edge of the mare, where it almost joins in a peak with the more dramatic Montes Apenninus, bordering the giant Imbrium Basin to the west.

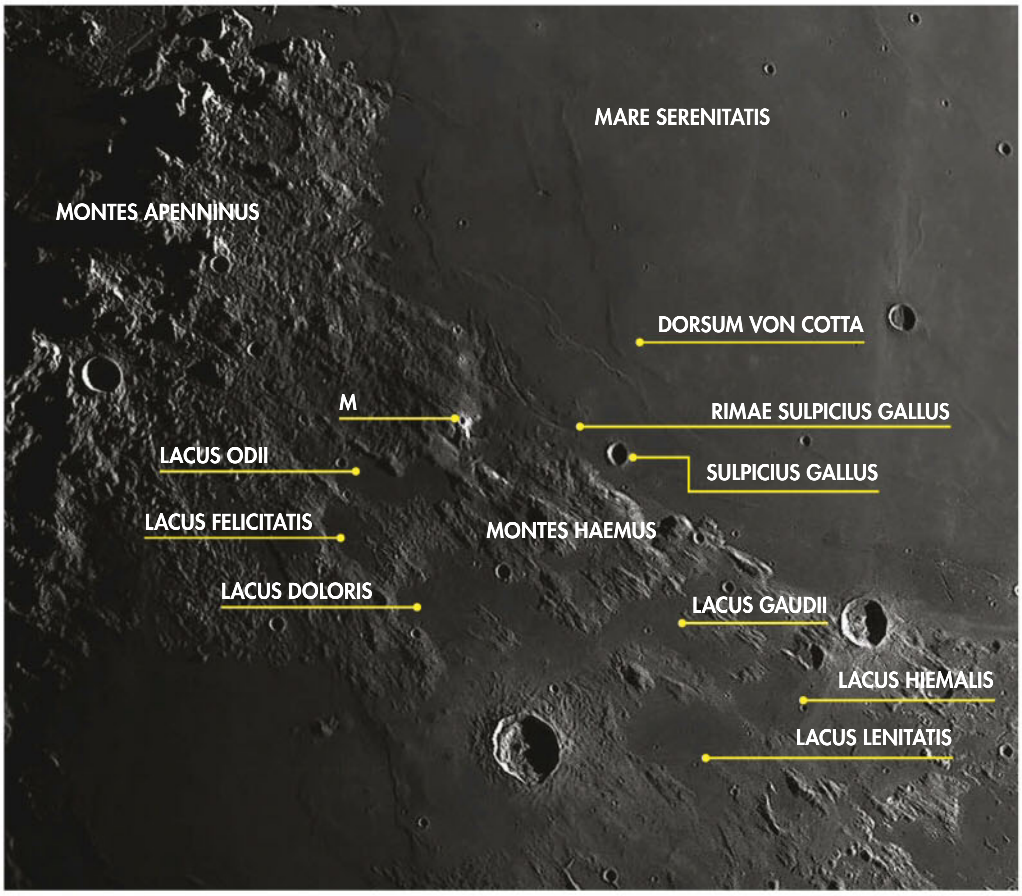
The region southwest of Montes Haemus is a mixture of mountainous terrain and low regions that have been flooded by dark lava. These carry some odd names such as Lacus Odii (Lake of Hate), Lacus Felicitatis (Late of Happiness), Lacus Doloris (Lake of Sorrow) and Lacus Gaudii (Lake of Delight). There are so many lunar lakes here that it is a bit like the Moon's version of the Lake District.

STATISTICS

TYPE: Crater
SIZE: 12km
AGE: Less than 1.1 billion years
LOCATION: Latitude 19.6°N, longitude 11.7°E
BEST TIME TO OBSERVE: Six days after new Moon or five days after full Moon
MINIMUM EQUIPMENT: 4-inch refractor



> "Sulpicius Gallus is bright and has a rim that rises above the floor of the mare"



There are many features around the crater – you'll need a 10-inch scope to be able to spot them all

The region immediately west of Sulpicius Gallus contains a forking system of rilles known as Rimae Sulpicius Gallus. These require a 10-inch or larger scope to see well. The rilles start to the west of Sulpicius Gallus as a single crack in the lunar surface. As the crack heads west, it starts to curve to the northwest and splits into three. As it does so, it passes across a dark region of pyroclastic material laid down by volcanic activity. In fact this region is one of the largest pyroclastic deposits on the entire Moon.

A number of bright, young craters pockmark the area, one being Sulpicius Gallus M (5km), which lies on the southern edge of the dark pyroclastic region.

Under low illumination lots of subtle and interesting features appear. There are several domes here, such as Sulpicius Gallus 4 (16km) to the west of the main crater, and Sulpicius Gallus 2 (5km) to the east. A low illumination casting oblique light is required to spot them using a 8-inch or larger scope.

There's a lovely wrinkle ridge known as Dorsum Buckland that runs for some distance roughly parallel with the Montes Haemus on the mare floor. Following the ridge west, where it passes north of Sulpicius Gallus, there's a smaller ridge feature that appears to split and head north. This is known as Dorsum Von Cotta.

Astrophotography

Photographing Perseid meteors

RECOMMENDED EQUIPMENT
DSLR camera, tripod, lockable shutter release cable, spare charged batteries, extra memory cards for the camera

Background stars, direction of travel and even colour can help you to identify Perseid meteors

METEOR PHOTOGRAPHY ISN'T actually that hard to do. You need plenty of patience but, once set up, the process of catching a meteor on camera is a waiting game – a bit like celestial fishing.

The likelihood of recording a meteor is given by a statistical probability and this comes from knowing the profile of material that Earth is passing through in space. This is determined by the dogged determination of meteor observers who diligently record how many meteors from a particular shower they see from one night to the next. Taken together, this important data builds a cross section through the cometary dust stream causing the shower and helps to predict the shower activity from one year to the next.

Accurate reporting is important. But counting meteors from different showers against the wrong shower skews the data. Similarly, recording events such as satellite trails as meteors also gives a false picture of what's happening.

As meteor photography becomes more popular, it's fairly common to see these misidentifications occurring. The methods needed to link a trail back to a shower, although not 100 per cent foolproof, are pretty straightforward to apply. Learning how to do this can lead to an accurate determination of photographic yield rates for a particular shower and help refine the dust stream's profile too.

Fundamentally, for a meteor to even be considered part of a shower, its trail has to point back to the radiant. On a photo this is normally quite easy to determine because there will be background stars visible in the frame too. Selecting a field with bright, easily recognised star patterns really helps here.

Using a star chart, it's then possible to see whether the trail is coming from the right direction. It's worth bearing in mind that shower radiants are not static areas and will slowly drift in position over the course of several nights. See page 50 for the location of the Perseid radiant this month. You might think that determining the direction of travel taken by a streak of light across the night sky would be quite hard. However, here too, a bit of prior knowledge can help. Typically, a meteor trail will start faint and end bright. This causes the trail to widen on a photograph towards its end point.

Back in the days when meteors were recorded using film cameras, it was more common to use black and white film to record them because of its sensitivity over colour stock. Consequently, most published film-based meteor trails look white in colour. However, in modern times, high sensitivity DSLRs record meteors in colour and this too can give a clue to the direction of travel. The colour comes mainly, but not always, from atmospheric gases. A trail will typically begin green due to the excitation of high altitude oxygen. As the meteor descends, molecular nitrogen is excited changing the trail colour to pink. So if a trail can be extended back to the radiant, the part nearest the radiant should appear green and the farthest pink.

Exceptions to this occur if the meteor trail becomes exceptionally bright. When this occurs, the colour can be lost due to overexposure. An artificial satellite trail will appear white, occurring because of sunlight reflecting off some part of the satellite.

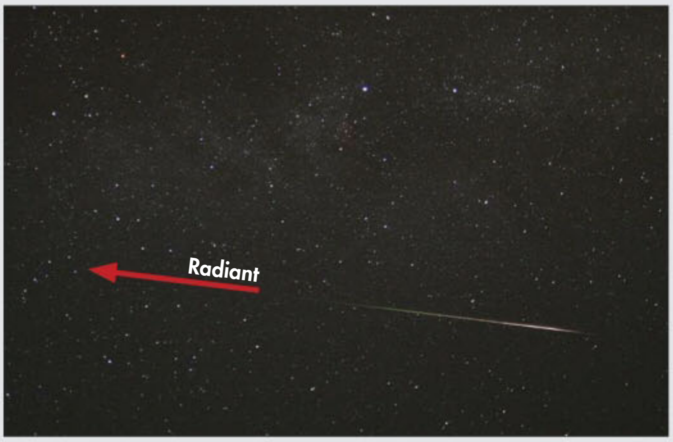
KEY TECHNIQUE
IDENTIFYING YOUR SUBJECTS
Just because a meteor shower is active doesn't mean that every streak you record belongs to it. During the period that the Perseids are on display there are also a number of other active lesser meteor streams. On top of this is the background sporadic meteor activity and artificial satellites resemble meteors on photographs too. Meteor photography is not just about capturing images – it is just as important to be able to recognise what type of meteor you've caught on camera.

ALL PICTURES: PETE LAWRENCE

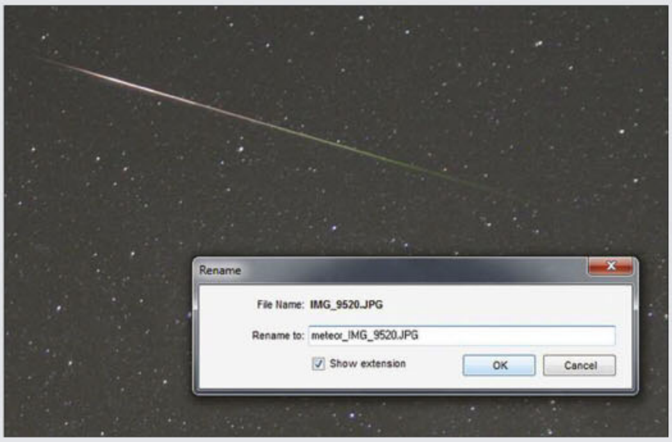
Send your image to: hotshots@skyatnightmagazine.com

STEP-BY-STEP GUIDE

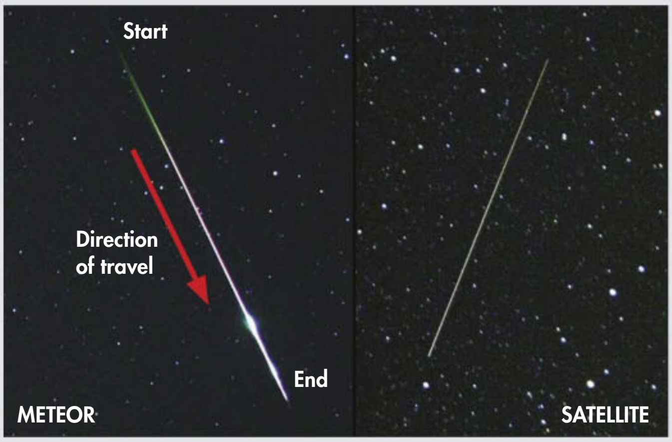
STEP 1 To photograph meteors you'll need a camera with at least a 30-second exposure capability, a lens with 14-28mm focal length and ideally a tripod for accurate positioning. Set the ISO high, typically 1600 or above. Set the lens fully open (lowest f-number). Focus accurately, preferably using live view on a bright star or planet. Finally, set the shooting mode to continuous shooting as indicated right.



STEP 2 Aim the camera at a point approximately 60° up and 45-50° from the radiant. Aligning the long axis of the frame so it points back to the radiant is also helpful. Set the camera exposure to 30 seconds, file type to large jpeg (RAW will fill the memory card quickly). Use a lockable cable release to lock the camera into continuous shooting mode.



STEP 3 Once the capture session finishes, transfer the images to a computer and flip through them sequentially. If you see a trail, rename the image with a "meteor_" prefix. When done, resort via filename to group the meteor shots together. Try to identify star patterns and the location of the radiant relative to the frame.



STEP 4 A Perseid trail must align with the Perseid radiant. Other showers are active in August so a genuine meteor trail may belong to one of these. If a trail aligns, see whether it has regular thickness and colour. A meteor trail typically starts green and then turns pink. A pure white trail is most likely a satellite.

STEP 5 Shower meteors will typically follow the rule that they appear shorter closer to the radiant. At the radiant itself, they may appear simply as a point of light. This is known as a pinpoint meteor. So a long trail that starts at the radiant is unlikely to be a Perseid. Similarly, a short trail a long way from the radiant is also likely to be a chance alignment.

STEP 6 If a flaring satellite passes through the camera frame, there's a good chance it'll be cut off between exposures. If a trail continues over two frames it's most likely a satellite. If it covers more than two, it's definitely a satellite! Look at the wide end of the trail. If it appears squarely truncated, it's most likely a flaring satellite cut off in its prime.

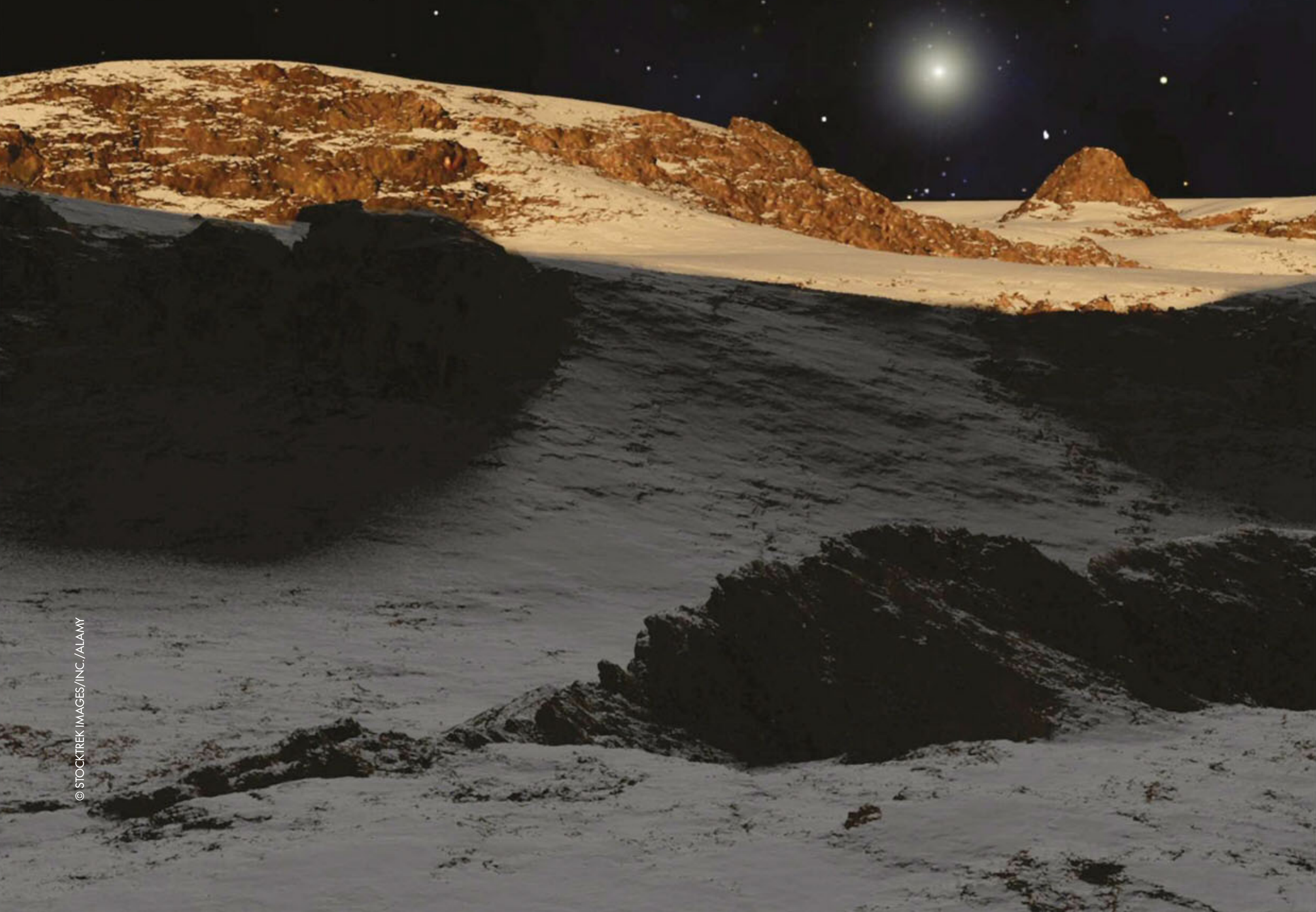
THE STORY OF PLUTO

In the past two centuries, Pluto has transformed from an orbital anomaly to a planet to the gatekeeper of the Kuiper Belt. **Paul Abel** recounts this twisting tale

There's a picture many have in their minds of Pluto, a magical image inspired by classic illustrations of the planets. Its surface is stark: a vast, desolate, icy plain stretching far into the distance, vanishing into a frozen gloom. Mountaintops glitter under a black sky full of stars, one of which is the Sun, though it is little more than a conspicuous star. The inner members of the Solar System are lost in the Sun's glare, and the underlying message is one of bleak isolation.

Today, we know only a little more about Pluto and the journey from discovery to its controversial reclassification is a fascinating tale. What started off as a curious orbital anomaly in the 18th Century turned into the discovery of an object that forced us to rethink our ideas of what a planet should be, and ultimately how our Solar System began. This is the story of Pluto.

By the mid 17th Century, a scientific revolution was in full flow. Kepler's laws of planetary motion, combined ▸



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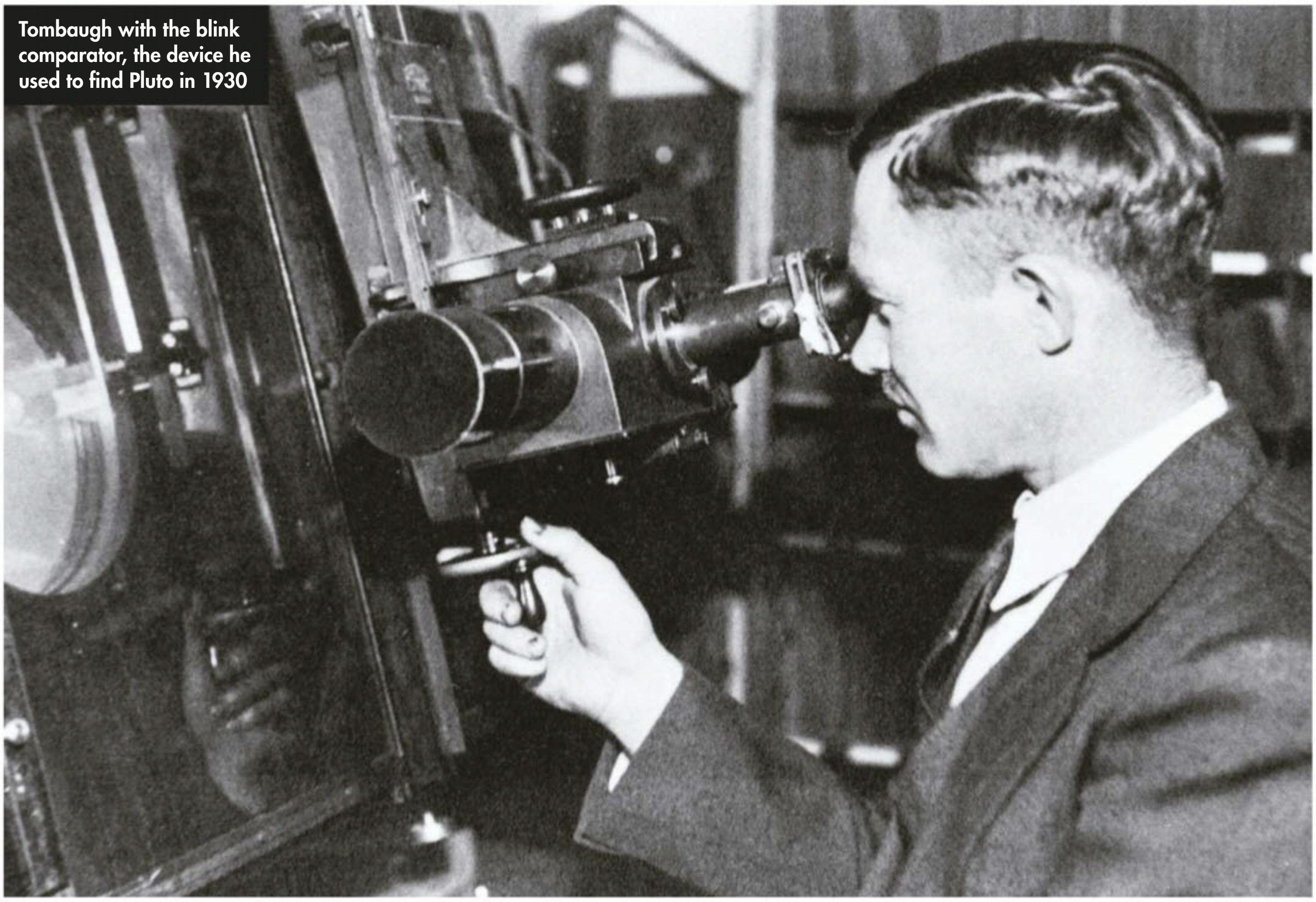
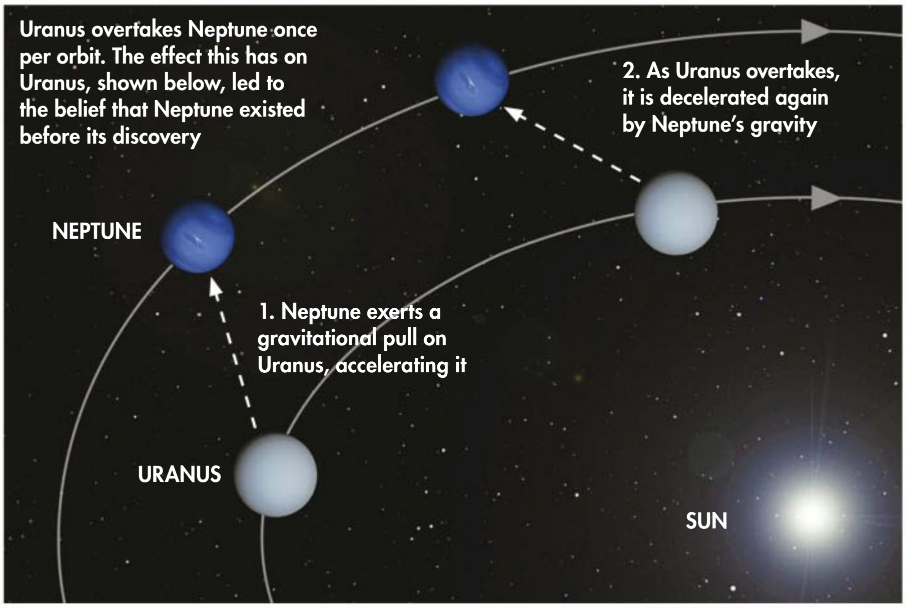


Tombaugh with the blink comparator, the device he used to find Pluto in 1930

▸ with Newton's law of gravity, provided astronomers with a powerful tool. The motions of comets and planets could be determined with absolute certainty. The prevailing view was of a Solar System that ran like clockwork.

However, by 1821 a curious anomaly had arisen – the recently discovered planet Uranus was not behaving as it should. The French astronomer Alexis Bouvard published tables of Uranus's position, but found that the planet frequently strayed from its predicted path. Perplexed, he realised that these discrepancies implied the presence of a large unseen body, tugging Uranus off course. Both John Couch Adams and Urbain Le Verrier predicted where this new planet might be. But it was Johann Galle and Heinrich d'Arrest who claimed victory, and the discovery of Neptune on the night of 23 September 1846 went to them.

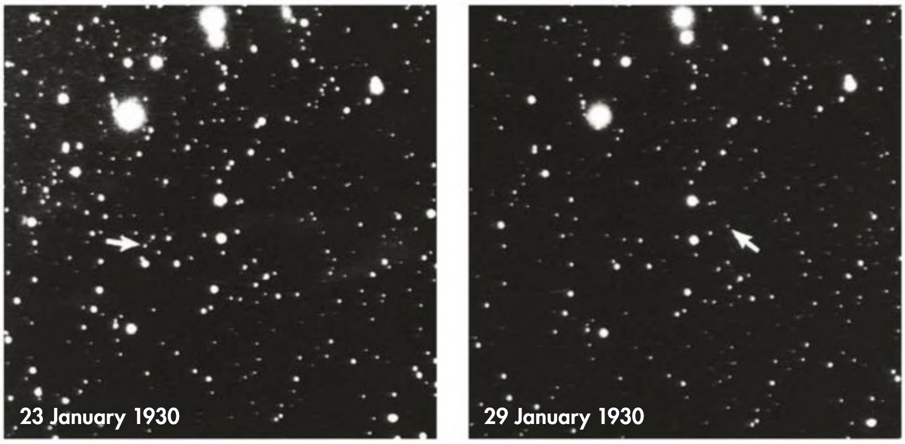
"By 1821 a curious anomaly had arisen – a recently discovered planet was not behaving as it should"



Uranus overtakes Neptune once per orbit. The effect this has on Uranus, shown below, led to the belief that Neptune existed before its discovery

So near, and yet...

Mathematicians set to work finalising the details of Neptune's orbit, but they found the discrepancies in Uranus's path around the Sun didn't completely vanish as expected. Something was still causing Uranus to wander. The problem was of keen interest to Percival Lowell, who had established a large observatory in the frontier town of Flagstaff, Arizona, in 1894. Lowell concluded that Uranus and Neptune were being drawn off course by another, more distant planet, which he named 'Planet X'. In 1906 he began searching for it, but after a decade Planet X had eluded him and he died in 1916. The



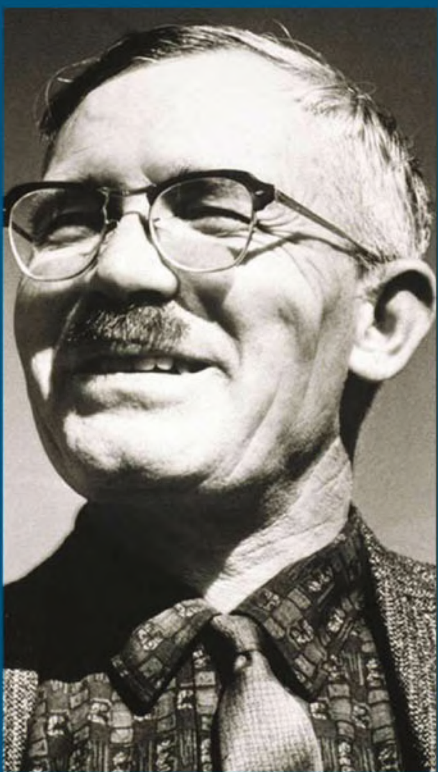
▲ **This is how Tombaugh found Pluto – he noticed that the arrowed dot moved between plates**

new director of the observatory, Vesto Slipher, continued the search.

In 1929, the task of searching for Planet X was given to a recent addition to the Lowell Observatory: Clyde Tombaugh. The work was hard – at night careful photographs were taken of the sky where Lowell had predicted the new planet should be. During the day, the plates were analysed using a 'blink comparator' – a device that switched back and forth between two photographs taken at different times. Looking through the comparator, stars remained fixed in position but a planet moving in its orbit would appear in a different location in each plate. On 18 February 1930, after months of searching, Tombaugh made a discovery: he noticed a tiny dot moving among the background stars of Gemini. The long search was over – Planet X had been found at last.

Planet X was named Pluto after the classical god of the underworld, but almost immediately there were doubts as to whether Pluto could really be Planet X. It was very faint, and its disc remained unresolved even in the world's largest telescopes. Pluto was obviously small, perhaps only the size of Earth or even Mars. It seemed ▸

▲ **The Pluto Discovery Telescope can still be visited at the Lowell Observatory**



▲ **Pluto wasn't Tombaugh's only accolade – he also discovered variable stars and comets**

THE MAN WHO **DISCOVERED PLUTO**

Clyde Tombaugh was just 24 when he made the find

Clyde William Tombaugh was born on a farm in Streator, Illinois, on 4 February 1906. Tombaugh had an interest in astronomy as a child, which was encouraged by his father and his uncle, who had his own telescope.

When the family moved to a new farm in 1922, disaster struck. A powerful hail storm destroyed much of their crops, and Tombaugh's plans to study astronomy at university had to be scrapped. Undeterred, he started to teach himself geometry, and in 1925 he set about building a large telescope of his own. The materials were expensive, so he took a second job in order to buy them. Unsatisfied with his first instrument, he laboured on for two years, polishing mirrors and grinding lenses, and in 1928 he produced a 230mm (9-inch) reflector he was satisfied with. Tombaugh had become a skilled telescope maker and would construct 30 more during his lifetime.

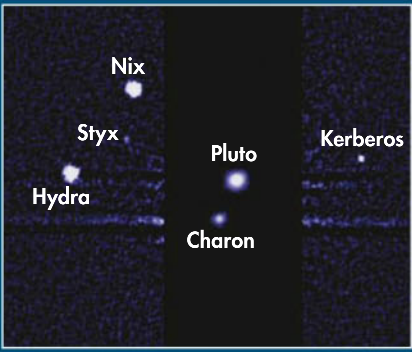
Tombaugh set to work with his creation under the dark Kansas skies and made many detailed drawings of Mars and Jupiter. He sent his drawings to Vesto Slipher, director of the Lowell Observatory, who was so impressed by Tombaugh's observational skills and draughtsmanship that he offered him a job. Tombaugh started at the observatory in 1929.

During the 14 years Tombaugh spent at the Lowell Observatory he was finally able to complete his education, obtaining his bachelors and masters degrees from the University of Kansas. Tombaugh made other discoveries during his time at Lowell, which included hundreds of new variable stars and asteroids, and two new comets. But his main achievement was the discovery of Pluto in February 1930.

After World War II he moved to New Mexico State University in Las Cruces, where he remained until he retired in 1973. Even into retirement he kept an active interest in astronomy and continued observing the night sky with his homemade telescopes into his early 80s. He died in 1997 and a small amount of his ashes were placed on the New Horizons spacecraft.

A WORLD OF **MYSTERY**

Our knowledge of Pluto's properties has grown a lot since 1930, but gaps remain



▲ **Pluto has five known moons, the latest – Styx – only discovered in 2012**

- Pluto is the largest member of the Kuiper Belt and part of a group of objects known as Trans-Neptunian bodies. These objects will reveal a lot about conditions in the early Solar System.
- Pluto has five satellites, the largest being Charon, at just over half Pluto's diameter. The other four are Nix, Hydra, Kerberos and Styx.
- Pluto's orbit is more like a comet's: it is inclined by 17° to the ecliptic. At times it is closer to the Sun than Neptune.
- Pluto's thin atmosphere is composed of nitrogen, methane and carbon dioxide. Remarkably, there is some evidence of winds blowing in the atmosphere.
- Pluto's surface varies greatly in brightness and colour. Patches of red, grey and white give Pluto's surface as much contrast as the Saturnian moon Iapetus.
- It's thought that Pluto's atmosphere could collapse and freeze as the dwarf planet moves farther away from the Sun; it is not known whether there enough heat to prevent this.
- Between 1994 and 2002/2003 some of Pluto's surface features appeared to change, with the northern polar region brightening up and the overall reddish hue of the surface increasing.

▲ **Images from Hubble show surface features changing over eight years**

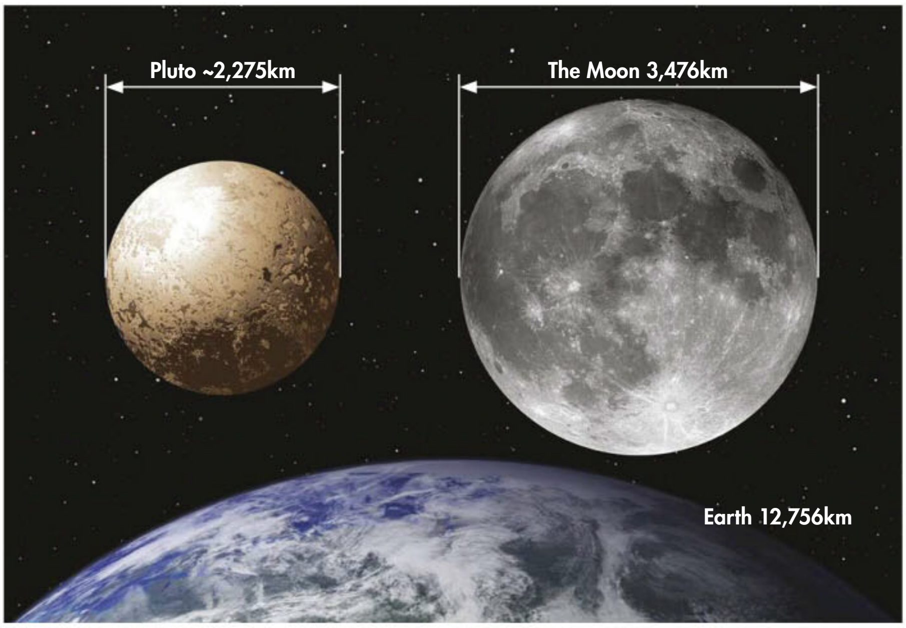
> **"It soon became apparent that there were many Pluto-sized bodies out beyond the orbit of Neptune"**

▸ unlikely it could have much influence over Uranus and Neptune.

Observing the planet was extremely difficult, but a handful of dedicated astronomers continued the work. Gradually, larger telescopes were constructed and observations showed that Pluto was probably covered with methane-ice.

In 1978, astronomer James Christy discovered Charon, Pluto's largest moon. Charon enabled astronomers to better estimate the mass of Pluto, which was much lower than expected – smaller even than Earth's own Moon. The small size, combined with its unusual orbit, began to cast serious doubt as to whether Pluto could really be a planet at all.

The 1990s saw the arrival of CCD cameras, which were much more sensitive to light than photographic film. They allowed astronomers to see fainter objects and peer deeper into the Solar System. Using CCDs it soon became apparent that there were many Pluto-sized bodies out beyond the orbit of Neptune. These objects belong to the Kuiper Belt, a vast field of debris left over from the formation of the Solar System, and Pluto was its largest member.



▲ **Once believed to be a massive world, Pluto is actually smaller than Earth's own Moon**

NASA/ESA AND M. SHOWALTER (SETI INSTITUTE), NASA/ESA AND M. BUIE (SOUTHWEST RESEARCH INSTITUTE), NASA, IAU/ROBERT HURT (SSC)

The first of many

From 2002 a host of large bodies were found: Quaoar, Sedna, Makemake and Eris. Loud astronomical voices began to debate Pluto's status. It was argued that if Pluto was a planet, were these other objects planets also?

In 2006, the International Astronomical Union (IAU) settled the matter and defined what was required for an object to be classed as a planet. One of the conditions is that all material must be cleared from the object's orbit, something Pluto hasn't done due to its small size. Pluto received a new classification: it was a dwarf planet, but this decision is not without its critics. Pluto may have been demoted, but it plays a vital role in understanding the conditions of the early Solar System. Kuiper Belt objects are like fossils: their ancient surfaces are like postcards from the past.

At the time of writing the New Horizons spacecraft is approaching Pluto. What will it find out there at the edge of the Sun's kingdom? It would be surprising if Pluto turned out to be geologically dead like the Moon. We've learned from Voyager and Cassini that geological life is abundant in the Solar System. The moons of Jupiter and Saturn are incredibly alive and diverse, and it's reasonable to think Pluto will hold its own strange marvels – perhaps cryovolcanism, nitrogen geysers like those on Triton, or stunning surface features sculpted by the striking seasons that Pluto endures. The chemistry of the atmosphere may also turn up some surprises. No doubt New Horizons will make many discoveries that will see new chapters written in the story of Solar System formation. As the data starts to arrive from our ambassador in the frozen twilight of the star system, the story of Pluto is just beginning.

New Horizons will have arrived at Pluto by the time you read this – check our website for the first images

ABOUT THE WRITER

Dr Paul Abel is an astronomer based at the University of Leicester. You can listen to him on our Virtual Planetarium each month.

SHOULD PLUTO BE REINSTATED **AS A PLANET?**

The two sides of the emotive decision to demote Pluto from full planetary status

NO

The official act that took planetary classification from Pluto was IAU Resolution 5A, 'Definition of a Planet in the Solar System', on 24 August 2006. This document states that for an object to be considered a planet must satisfy three conditions. It states:

"A planet is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, (c) has cleared the neighbourhood around its orbit."

Since Pluto is not massive enough to clear its orbit of debris, it fails to meet the third condition. There's also the problem that if Pluto were to be classed as a planet then so too would many other objects in the Kuiper Belt, and the planet count in the Solar System would rise dramatically.

YES

There are some who have argued to keep Pluto as a planet for sentimental reasons: for much of its history, it has been thought of as a planet and therefore should continue to be so.

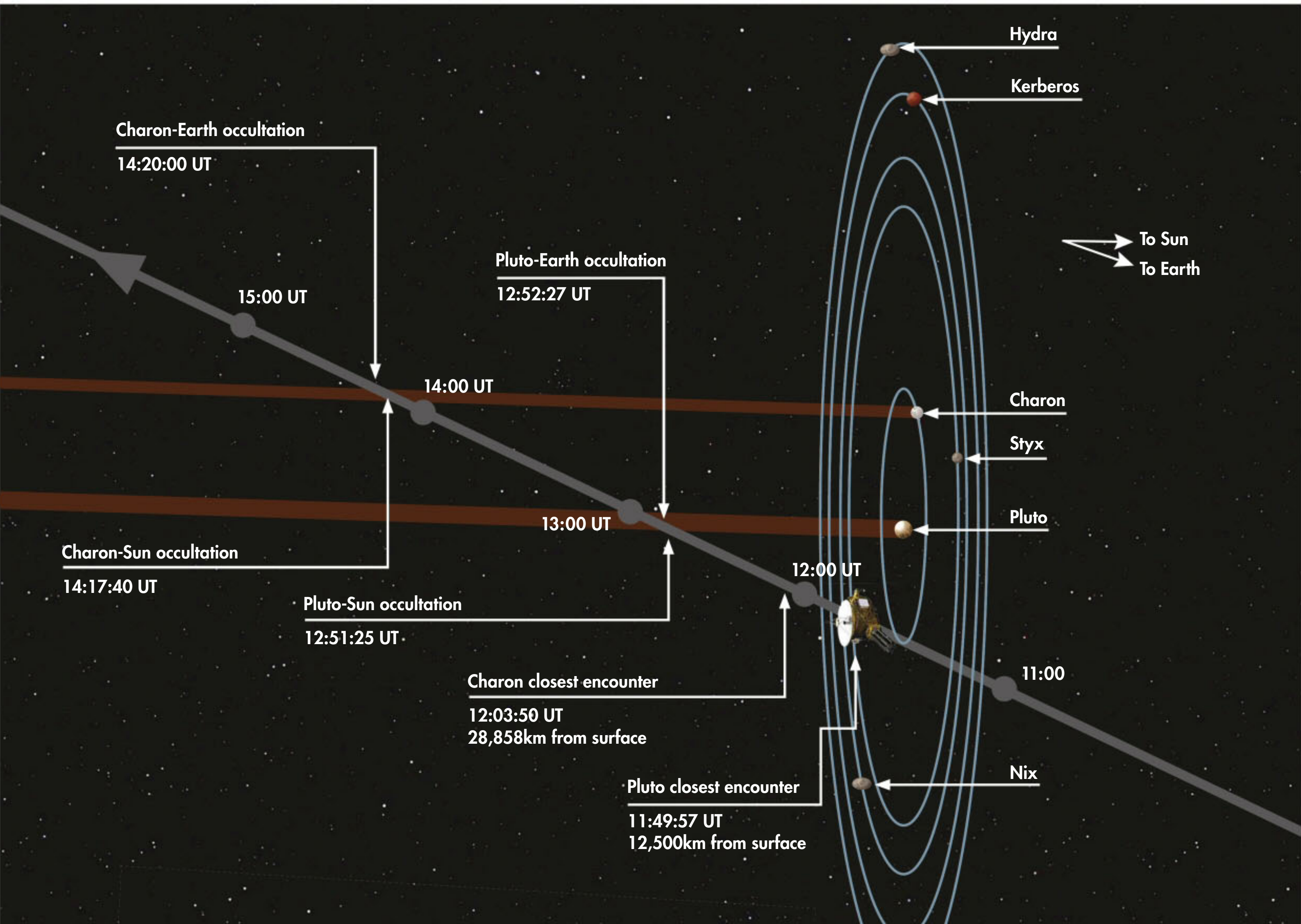
Some astronomers point out that there are inconsistencies in the wording of Resolution 5A – while it is true that Pluto hasn't cleared its orbit, neither has Earth or Jupiter. Earth orbits with 10,000 near-Earth asteroids, while 100,000 Trojan asteroids lie within Jupiter's orbit. One could argue that both Jupiter and Earth also fail the IAU definition. Those who hold this view say that a better definition of what a planet is might be to say that any object orbiting the Sun that has a surface area greater than 1,000km can be called a planet. If this definition were to be adopted both Pluto and Eris would be classed as planets.

The IAU voted to demote Pluto in August 2006

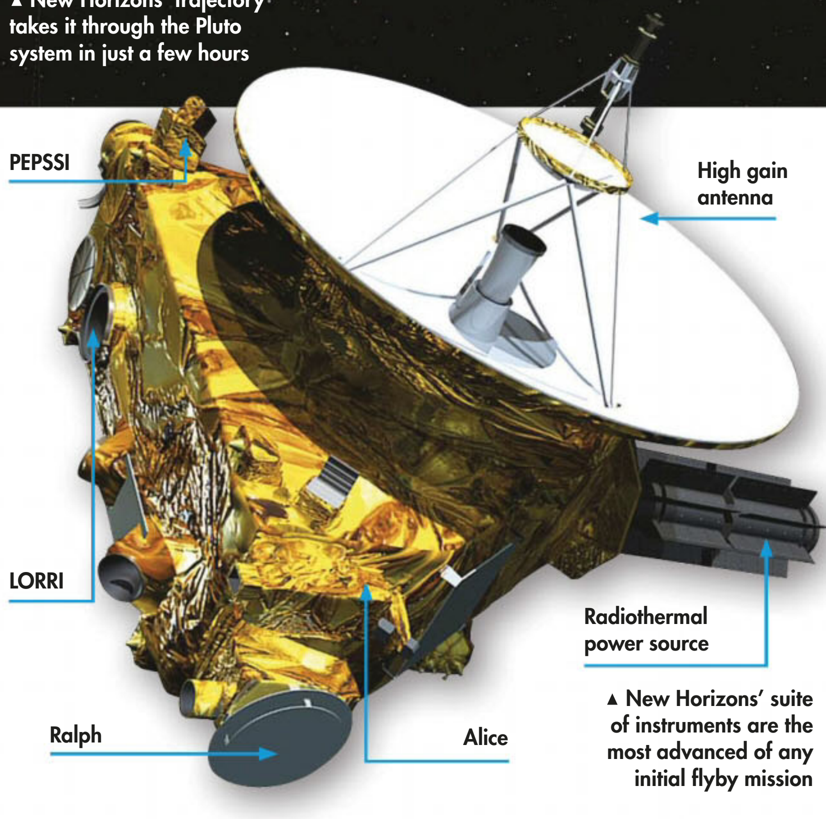
THE LAST NEW HORIZON

When NASA's New Horizons reaches Pluto it will complete our exploration of the Solar System. **Elizabeth Pearson** reveals what the probe hopes to find

NASA/JHU APL/SWRI/STEVE GRIBBEN, MARK GARLICK/SCIENCE PHOTO LIBRARY



▲ New Horizons' trajectory takes it through the Pluto system in just a few hours

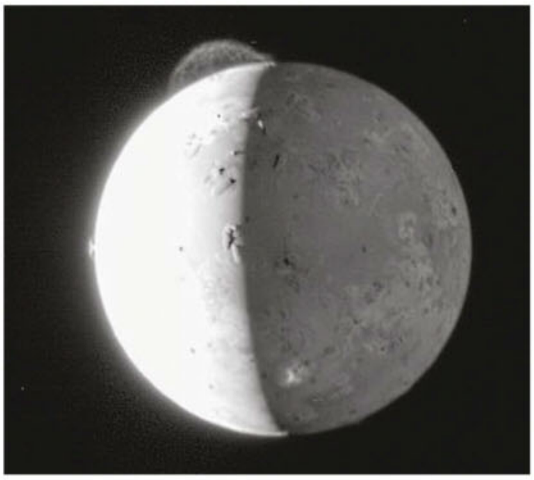


▲ New Horizons' suite of instruments are the most advanced of any initial flyby mission

On the outskirts of the Solar System lies a cold and distant realm, filled with icy inhabitants. Humankind has never visited this place before, but by the time you read this that will no longer be true. New Horizons will have visited Pluto.

The spacecraft will fly past the dwarf planet on 14 July, several days after this issue went to press. The highest quality images from this flyby should begin appearing on the evening of 15 July, and the world will see the first clear shot of the last major milestone in our Solar System.

It has taken the spacecraft over nine years to traverse the near 5 billion km to reach the dwarf planet, launching at a record speed of 58,500km/h. The probe couldn't carry enough fuel to slow down from this speed and enter Pluto's orbit, so instead it will zip past on a flyby. But NASA is not going to waste the short time it does have near the dwarf planet. The grand-piano sized space probe has been kitted out with the most advanced set of instruments



▲ New Horizons will use reflected light to image the dark areas of Pluto, just as it did with Io (above) in 2007

that has ever been created for an initial flyby mission, ready to carry out a full science programme that will span the nine days around the encounter.

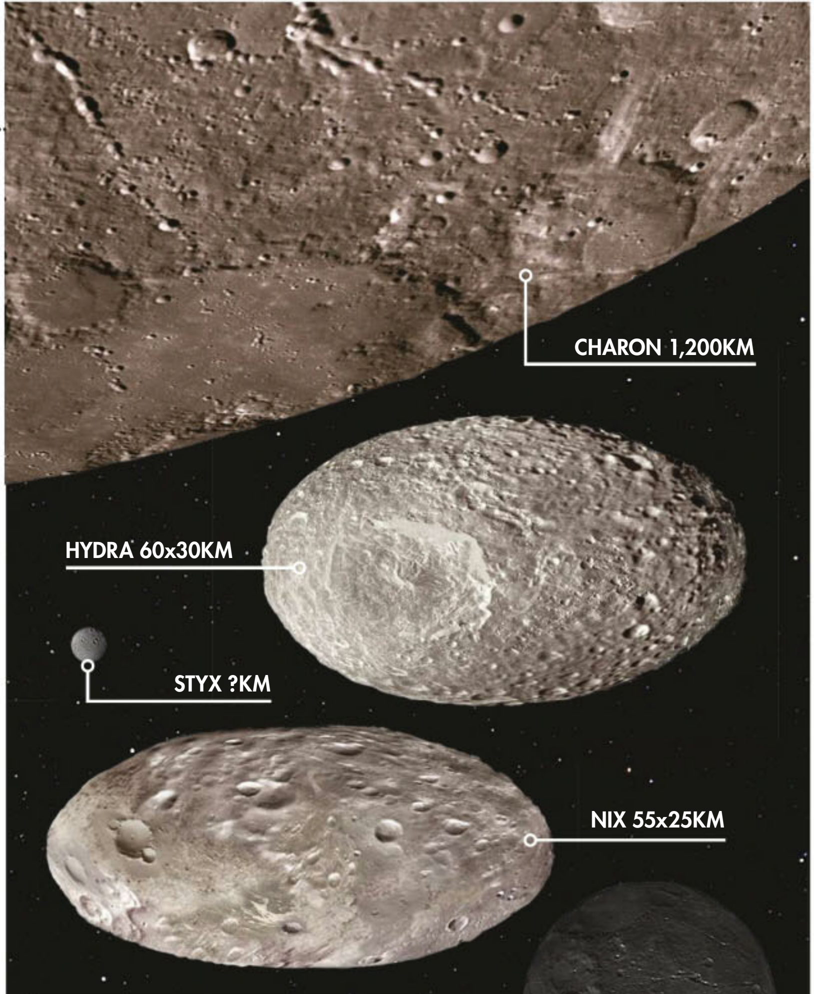
"We are in a mission of almost pure discovery," says New Horizons co-investigator William McKinnon, professor of Earth and planetary sciences at Washington University in St Louis. "We've never seen a small planet in the Kuiper Belt before. We're taking as much data with as many instruments as we can in the weeks leading up to the encounter and afterwards, taking breaks to phone home and send back data to make sure we get some images no matter what happens."

Fleeting opportunity

As New Horizons closes in the observing plan will get more focused, aiming to get the most out of the short time the probe will spend in flying past Pluto. The observations have been carefully planned to ensure as much coverage as possible. It takes Pluto 6.4 Earth days to rotate about its axis, meaning that most of its surface will be illuminated by the Sun at some point during the flyby and approach. However, like most other bodies in our Solar System, Pluto's rotational axis is off-kilter, meaning part of its surface will be permanently in shadow, but the team have managed to get around this.

"We're going to try and use reflected light from Charon to illuminate Pluto to see the parts of the dwarf planet that are in darkness because of its seasons," says McKinnon. "These moonlit images won't have the same detail of a solar-illuminated image, but we'll be able to see frost patterns."

Creating such a complete picture is important because we haven't seen Pluto up close before and no one knows exactly what to expect. A mission like New Horizons is designed to leave behind a legacy, a set of maps and data that scientists can use for years to come. Firstly, the LORRI (Long Range Reconnaissance Imager) and Alice cameras will take visual images that will create an atlas of surface features. Then two spectrometers – Ralph and PEPSSI (Pluto Energetic Particle Spectrometer Science Investigation) – will overlay the composition of ▸



◂ In 2006, we only knew about three moons; Kerberos and Styx were only discovered in 2011 and 2012

A MULTITUDE OF MOONS

While most eyes will be turned on Pluto, its moons are just as fascinating

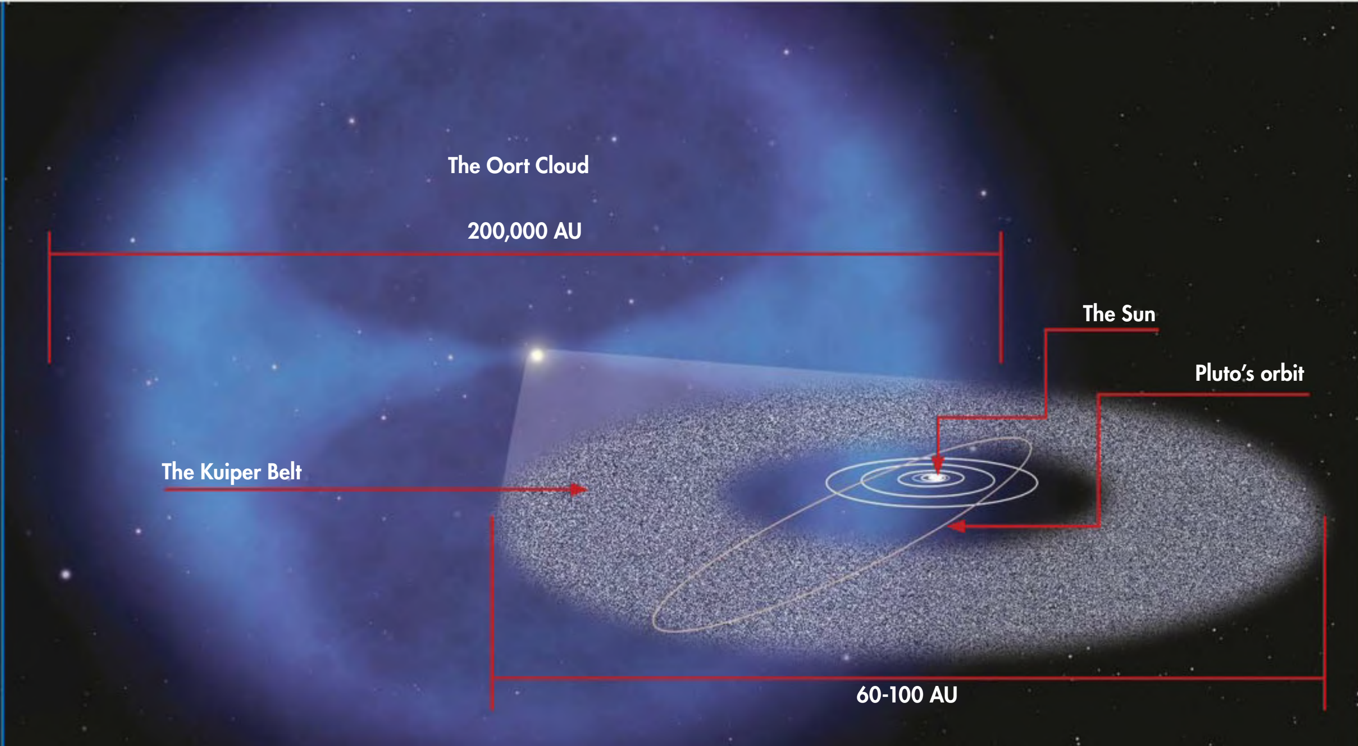
Before New Horizons came to Pluto the system had five known moons – Charon, Hydra, Nix, Kerberos and Styx – but the mission may uncover more.

Pluto's largest moon, Charon, measures around 1,200km in diameter and is covered in water-ice. There are hints that there may be cryovolcanism on the moon, where huge geysers of liquid water from the core break through the surface like volcanoes on Earth.

The moon and dwarf planet make up a binary pair – Charon is so large the centre they orbit about is actually outside of Pluto's body. This means that the pull of gravity around the two is constantly shifting, throwing the smaller moons into a tumble.

New Horizons will give us a closer look at the small moons. At the time of writing we had already learned much about these worlds, though the more we learn the more questions arise.

While most of the moons are the colour of sand, Kerberos is as dark as charcoal. A closer look will help us to determine why this one world should look so different, though it is likely the answer will only create more questions about how our Solar System first formed.



THE KUIPER BELT

The Solar System is ringed in objects that never quite made it to be planets or moons

After the discovery of Pluto the idea arose that it was part of a great ring of objects similar to the asteroid belt, but made up of icy bodies instead of rocks. It was named the Kuiper Belt, after Gerard Kuiper who, along with Kenneth Essex Edgeworth, proposed it in 1951.

The search to find other objects in this distant region of space was on, but it wasn't until 1992 that another large object was found – 1992 QB1. Since this discovery over a thousand more objects have been added to the list, including the dwarf planets Eris, Haumea and Makemake.

While New Horizons is humanity's first visit to an object in this distant realm, we have seen Kuiper Belt objects before in the form of comets. Short-period comets, such as 67P/Churyumov-Gerasimenko, which the Rosetta mission landed on, originally started life in the Kuiper Belt before their orbits were disrupted to bring them closer to the Sun. These celestial messengers bring us a snapshot from the dawn of the Solar System and insight into how the worlds around us were first created.

There is also believed to be another halo of icy objects even further out, known as the Oort Cloud, though this theoretical zone has yet to be observed.

▸ the dwarf planet, picking up on the signatures of methane, water and other chemicals that have already been detected on the surface.

But it's not just the surface that will be revealed: so too will the dwarf planet's atmosphere. Watching the sunlight as it is reflected off and passes through the atmosphere will tell us what chemicals it contains. Other instruments will map its temperature, pressure and rate of loss.

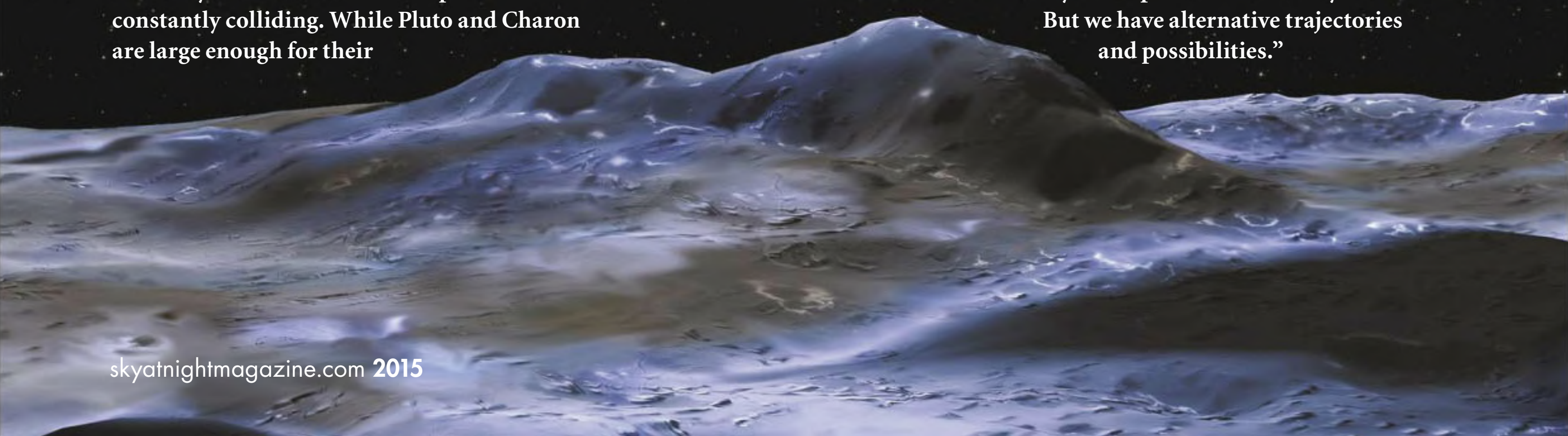
Crash danger

As the craft flies through the system the Student Dust Counter instrument – designed and built entirely by University of Colorado Boulder students – will measure the concentration of dust particles in the outer Solar System. As New Horizons closes in on Pluto it's these dust particles that pose the biggest threat to the mission.

The icy inhabitants of the Kuiper Belt are constantly colliding. While Pluto and Charon are large enough for their gravity to capture any ejecta from an impact, the smaller moons are not. The ice and dust kicked up is instead flung out into space. At the speeds involved it would only take an ice chip the size of a grain of rice hitting the wrong place to destroy New Horizons. It's also possible that an as yet unseen moon or ring system could exist along the probe's flight path.

But the mission team have been keeping a watchful eye, and things are looking good.

"I am not that worried," says McKinnon. "We don't expect to find new moons or debris in the path of the mission. We're flying through the very safest part of the whole system. But we have alternative trajectories and possibilities."



If the ship survives its encounter with Pluto, it will still be a long time before the full extent of its data gets back home. On flyby day New Horizons will be nearly 5 billion km from Earth, meaning it will take the transmission four and a half hours to reach us, even travelling at light speed. The radio signal is only 12W in strength, around the same as an energy efficient light bulb. "The data comes down at 2kb/s," says McKinnon. The average speed of broadband internet is 5,000 times faster. "We're not going to have it all down until 2016, so it really won't be over for us for a long time."

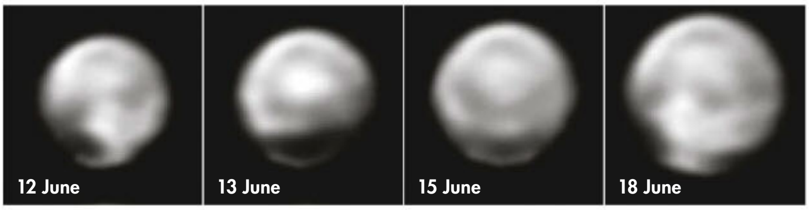
All of the images should be downloaded within two months, but it could take as long as 16 months for all the data to be sent back to Earth. Once the information is here, researchers will begin putting it all together. This is where the real discoveries begin. Until those first images start to come home, no one is really sure what we're going to find.

"We've never done anything like this before," says McKinnon. "It's unfinished business from the 20th Century – the first mission to the last planet. But in reality we are opening the door into a new region of space. Pluto is not alone – it has brothers and sisters out there."

There are already plans to visit at least one other Kuiper Belt object with New Horizons, and the Hubble Space Telescope has helped find three candidates – currently designated PT1 (PT being 'potential target'), PT2 and PT3. After the encounter with Pluto, New Horizons will be redirected towards one of these between October and December, transmitting the data from Pluto home as it makes the long journey onwards.

By the time you read this, the first of the approach photos should already be back on Earth, but they won't be the last. It will be an exciting year ahead as the secrets of the last unknown world in our Solar System are finally uncovered. Ⓢ

"IT WOULD ONLY TAKE AN ICE CHIP THE SIZE OF A GRAIN OF RICE HITTING THE WRONG PLACE TO DESTROY NEW HORIZONS"



▲ ► At the time of going to press these were the best images taken by New Horizons, showing clear dark and light surface markings on Pluto

▼ This deconvolved image of Charon taken on 18 June reveals surface features on the moon too

ABOUT THE WRITER

Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s news editor, specialising in space science. She gained her PhD in extragalactic astronomy at Cardiff University.

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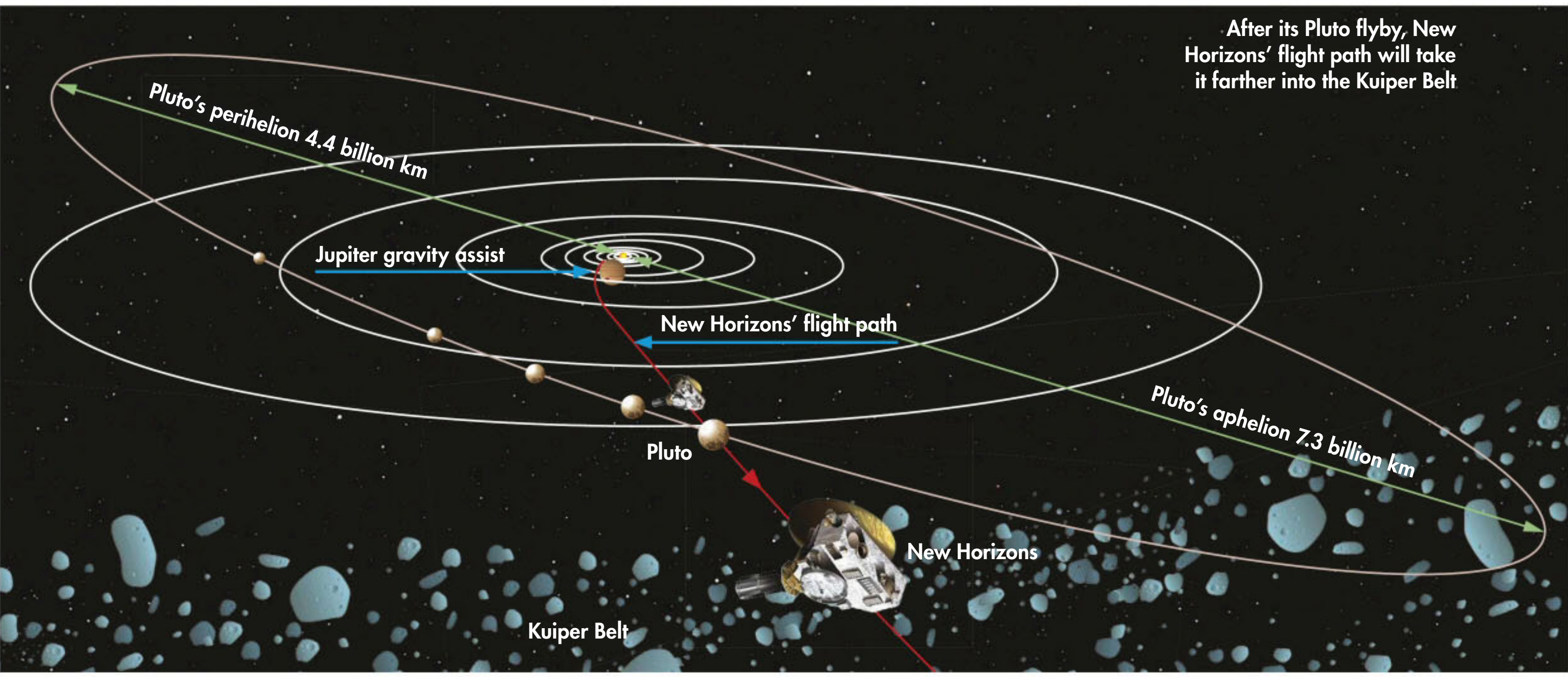

After its Pluto flyby, New Horizons' flight path will take it farther into the Kuiper Belt

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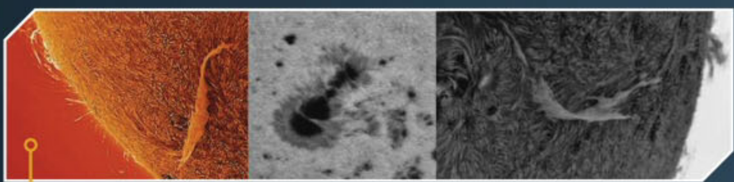

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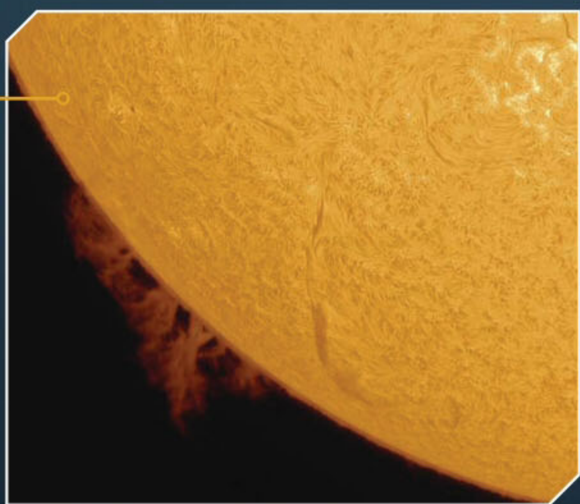

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Justice beyond the atmosphere

As more nations head out into space, space law expert **Sa'id Mosteshar** looks at what international law is doing to keep up.

ABOUT THE WRITER

Sa'id Mosteshar is the director of the London Institute of Space Policy and Law (ISPL), member of the UK Space Leadership Council, and advisor to the UK delegation to the UN COPUOS.

As mankind pushes further among the stars the lawlessness of space is becoming a concern. It is no longer the domain of two governments but dozens, and an increasing number of private companies. There are already plans in place to begin mining asteroids, put people on Mars and take space tourists out beyond low-Earth orbit. Is the law doing enough to keep up with those who are pushing the final frontier?

The first obstacle to governing outer space is deciding where it ends and airspace begins. As satellites can orbit down to as little as 120km, a good working definition is 100km above sea level. So, is there law 100km above our heads? No – and yes. No country or other law-making body can extend its jurisdiction into space. However, an international body of laws, mainly UN treaties, can govern our activities there. People, objects and uses of space are subject to a form of legal regime. Even before the launch of Sputnik in 1957, some were contemplating principles that should apply in outer space. The 1962 UN Resolution led to the Outer Space Treaty of 1967.

Far-sighted, but still limited

There are several main principles that the Outer Space Treaty aims to instil. First it states that every country has the right to explore and use outer space. Space cannot belong or be subject to the rule of any one country, but each spacefaring nation is responsible for regulating and supervising its activities, whether government or private. Laws at a national level continue to grow from this fundamental idea. The treaty also covers liability for any damage that one country's activities causes to another nation or its citizens, and states that ownership of an object lasts while it is in outer space. ▸

Tourism is likely to be one of the focus points of future space law

▲ UK satellites must prove they can protect the privacy of anyone caught on their cameras

THE UK ROLE IN **SPACE LAW**

As the UK's space sector grows, its lawyers are leading the way

The UK has a strong academic, governmental and commercial space sector. Its regulatory system is regarded as an example by many countries that are contemplating or have recently regulated space activities. By participating in the UN Committee on the Peaceful Uses of Outer Space and its subcommittees, the UK further helps to shape international law.

The UK passed its Outer Space Act in 1986, the third country to do so after the US and Sweden. It provides the regime for the government to authorise and regulate private space operations by UK nationals, including companies. Under this act, UK operators must apply for a licence before they are allowed to launch anything into outer space. The requirements to meet the licence depend on the type of object being launched, and can cover anything from ensuring the satellite is safe to operate to ensuring Earth viewing satellites maintain the privacy of those it may photograph. It also requires space system operators to insure against claims for damages, much like when driving a car.

The UK closely cooperates with the US, both in how it regulates space activities and by exchange of information. ESA also cultivates a strong and bilateral relationship between its many member states. The UK is an active participant and spends most of its space budget on contributions to ESA.

▲ Mining is a grey area: the Outer Space Treaty makes it illegal for any company to claim ownership of extracted resources

► This treaty was a remarkable achievement, involving all countries of the UN, and ensured that the actions of the two major spacefaring nations of the time – the US and the Soviet Union – were acceptable to the international community. The result was far-sighted, recognising a future of commercial space activity though at the time none existed.

But in recent years there has been a massive rush to this region 100km over our heads. As more people send objects out into space, new laws are needed. One aspect that was not addressed adequately in the Outer Space Treaty is the exploitation of outer space, and space technology is beginning to push up against these limitations.

The treaty does not allow extracted resources from outer space to be owned by any country, nor its nationals. If a company spends several billions to mine an asteroid, not legally owning the product would be a financial disaster.

But all is not lost. Another treaty, the Moon Agreement of 1979, allows for the exploitation of space resources, but requires that when it becomes feasible, a regime must be agreed to share the benefits fairly. There is already a model for this in the International Seabed Authority. The problem is that only 15 countries have joined the Moon Agreement, and none is a major spacefaring nation.

Who deals with the litter?

There is also the problem of space debris. At orbital speeds it can take as little as a fleck of paint in the wrong place to render a satellite defunct. Satellites left drifting in space are at risk of

THE LAWS OF **SPACE**

The rules governing legal affairs beyond Earth mainly stem from five UN treaties

The United Nations Office for Outer Space Affairs is responsible for overseeing the fair usage of space, and has created several treaties to ensure it. The UK has, along with many other countries, ratified the four of its treaties into law, but is yet to sign the Moon Agreement.

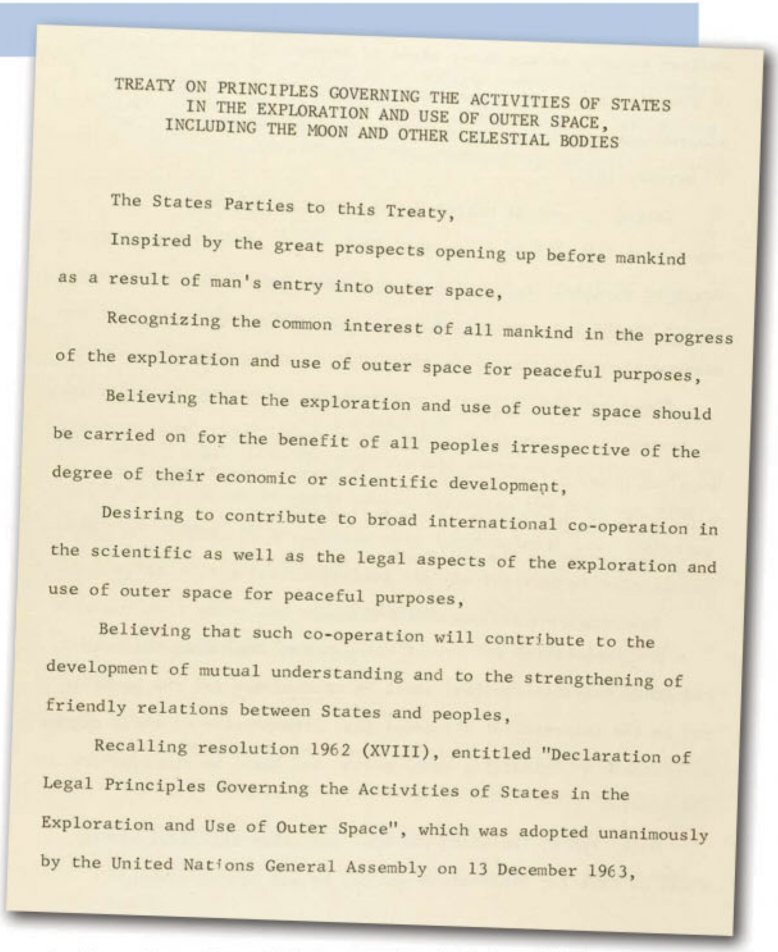
▶ The Outer Space Treaty 1967 establishes international legal principles in outer space, including the right of all countries to explore and use outer space, fixing responsibility for their governmental or private actions. It attaches liability for damage, on Earth and in space, caused by space objects including satellites.

▶ The Rescue Agreement 1968 concerns Outer Space Treaty obligations to speedily assist astronauts in distress and to return space objects.

▶ The Liability Convention 1972 concerns liability imposed under the Outer Space Treaty. The country that launched an object must pay damages to a country if it or its citizens suffer damage. Fault must be shown if damage is to another space object, but not to property on Earth or to flying aircraft.

▶ The Registration Convention 1974 requires countries to register space objects they launch and to notify the UN where a central register is kept, enabling others planning space activities to know where objects are, and which country is liable for damage.

▶ The Moon Agreement 1979, in force 1984, concerns all celestial bodies including asteroids. It sets out the circumstances under which outer space can be exploited, so that all countries benefit.



TREATY ON PRINCIPLES GOVERNING THE ACTIVITIES OF STATES
IN THE EXPLORATION AND USE OF OUTER SPACE,
INCLUDING THE MOON AND OTHER CELESTIAL BODIES

The States Parties to this Treaty,

Inspired by the great prospects opening up before mankind as a result of man's entry into outer space,

Recognizing the common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes,

Believing that the exploration and use of outer space should be carried on for the benefit of all peoples irrespective of the degree of their economic or scientific development,

Desiring to contribute to broad international co-operation in the scientific as well as the legal aspects of the exploration and use of outer space for peaceful purposes,

Believing that such co-operation will contribute to the development of mutual understanding and to the strengthening of friendly relations between States and peoples,

Recalling resolution 1962 (XVIII), entitled "Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space", which was adopted unanimously by the United Nations General Assembly on 13 December 1963,

▲ The Outer Space Treaty 1967: among its stipulations, this document bans weapons tests and military bases, and outlaws claims of sovereignty

NASA, © CORBIS, DAVID DUCROS/SCIENCE PHOTO LIBRARY, ESA/MIXED-REALITY COMMUNICATION GMBH


With the tiniest impact capable of causing havoc, space debris is a rising concern amongst lawmakers

> "It is not yet international law, nor is there a requirement to remove current space debris"

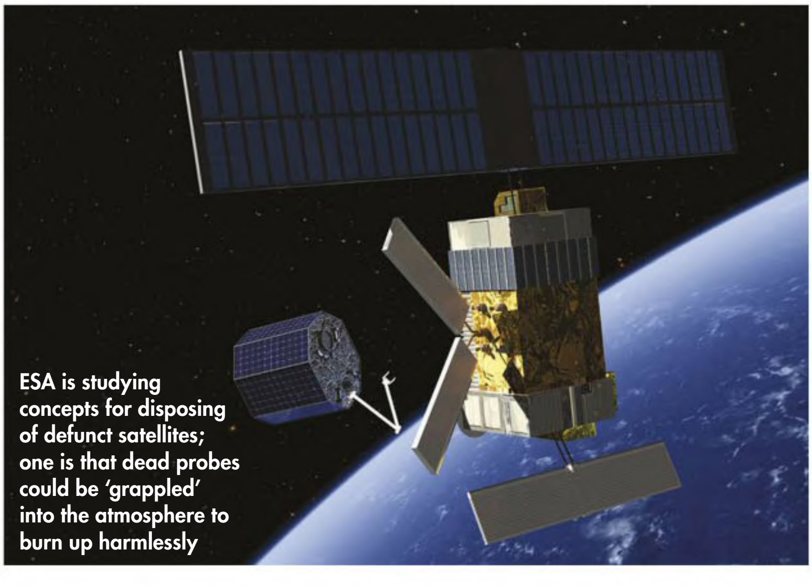
colliding with others, smashing into thousands more dangerous fragments and so worsening the problem. Ideally, the legal regime would include a provision to stop the creation of new debris by limiting the length of time space objects are left in orbit beyond the end of their usefulness. Though most national licensing agreements require satellites to be out of low-Earth orbit 25 years after their lifetime's end, it is not yet international law, nor is there a requirement to remove current space debris. The debris in low-Earth orbit is already at critical levels. Even if no more satellites were ever launched, at least five pieces of 5kg debris would need to be removed a year to keep this orbit usable.

To deal with debris you have to find it. Currently the US Department of Defense tracks objects as small as 5cm in low-Earth orbit and as small as 1m in geosynchronous orbit. Plans are in motion to make this more sensitive. Systems are being developed to collect and dispose of debris too, but they may require the agreement of the owner or a permit.

Recent codes of conduct, adhered to by all space-active countries, aim to reduce debris generation. ESA and others are developing systems to remove already existing debris. What is not yet clear is who will fund them.

One area that is likely to explode in the next few years is space tourism. The vehicles currently planned by companies such as Virgin Galactic are not designed to remain above 100km, although some may briefly go beyond this altitude. This, in combination with other technical characteristics, has led the UK Civil Aviation Authority to determine that they be treated as aircraft, albeit experimental ones. However, if any system is treated as being in space and not subject to the liability regime developed for aircraft, there must be an agreement addressing liability. Interestingly, many legal systems, including EU members and some US states, do not permit waiver of liability for personal injury or death, meaning companies are liable regardless of any agreement made with the potential astronaut beforehand.

Mankind's exploration of outer space is entering an exciting new era and new laws need to be created – not just on a national level, but on the international stage – if we want to maintain space as a peaceful venture for all of mankind.


ESA is studying concepts for disposing of defunct satellites; one is that dead probes could be 'grappled' into the atmosphere to burn up harmlessly

The Guide
A beginner's guide to mounts

With **Paul Money**

The basic types explained, plus what to consider when buying

Try holding even a small telescope for any length of time and it will quickly become apparent that you need something to support it – this vital piece of any setup is the mount. There are several types, and which one is best for you, and indeed how much you'll have to pay for it, depends on what you want to use your telescope for. The mounts available to today's amateur astronomers suit a range of needs, from a simple tripod right up to a sophisticated instrument fit for an observatory.

Most mounts are a variant of two basic designs, altazimuth (altaz) and equatorial. Altaz mounts move in two axes, one perpendicular to the horizon (altitude, giving an up and down motion) and the other parallel to the ground (azimuth, giving horizontal motion), but most basic designs cannot track the sky – though there are a few exceptions.

In equatorial mounts, one of the axes is parallel to that of Earth's rotation, meaning they can track the night sky and keep targets centred in the field of view, provided they are properly polar aligned prior to use. This makes them ideal for prolonged observing or for long-exposure astrophotography.

There are other considerations to take into account. If you want a permanent setup, then a heavy-duty mount with excellent tracking would be ideal. Being portable and easy to set up may be a more practical solution for some, perhaps where space is limited, so a lightweight but robust mount could be a better choice.

Similarly, you need to consider the mount's payload capacity – in other words, how much weight can it support? Remember, if you want to do any astrophotography, this weight has to account for all of your kit, not just the telescope. Can the mount-telescope system be easily dismantled if

△ ALTAZ MOUNT
The simplest form of altaz mount is the humble tripod, which is easily portable and comes in a variety of styles – from lightweight models to sturdy affairs that are more than capable of holding a small refractor or small compound telescope. Dual-mounting manually operated altaz tripod mounts are also available.

△ DOBSONIAN MOUNT
Devised by renowned amateur John Dobson, the Dobsonian is a simple rocker box on a turntable made from basic materials that supports a large Newtonian reflector. The design is an easy to use, manually operated altaz system, although there are now some computerised models that can track the sky.

△ GERMAN EQUATORIAL MOUNT
A popular mount design that allows for the tracking of the stars as Earth turns by having one axis parallel to our planet's rotational axis. With a variety of mount carrying capacities – from non-motorised mounts up heavy-duty tracking systems suitable for an observatory, this is the mount of choice for many.

ISTOCK, PAUL WHITFIELD, WWW.SECRETSTUDIO.NET

△ CAMERA TRACKING MOUNT

A recent addition to the astronomical mount family, these mounts attach to a standard tripod and the hinge is angled towards the celestial pole, allowing for tracking with a camera so long as a polar alignment is performed during set up. Many can even support small telescopes, making them useful if you want to travel abroad or head to an observing location away from home.

△ FORK MOUNT

Fork mounts hold the telescope tube either via a single arm or two and are typically altaz, though they can be converted to equatorial using an equatorial wedge. Motorised or computerised fork mounts can move the telescope through the southern meridian without requiring a meridian flip, allowing for imaging sessions across the meridian, which is a problem for German equatorial mounts.

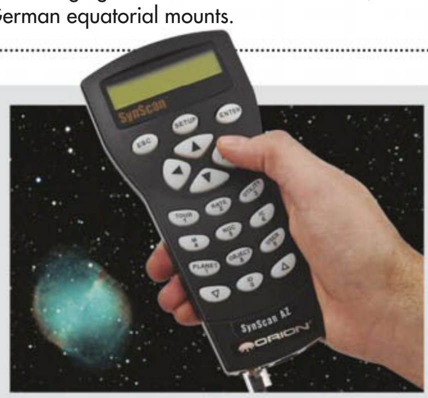
the clouds roll in or, conversely, set up quickly if a patch of clear sky appears? If you're thinking of a computerised mount, you need to check to see if it has the relevant ports for any accessories you might want to use.

Choosing a mount can be a daunting thing; there are a lot of options. But it is also true that there is a suitable mount for all occasions. With a little consideration you should be able to choose the right one for your needs. S

Paul Money is *BBC Sky at Night Magazine*'s reviews editor

GRAB AND **GO-TO**

Go-To is a computerised set up involving a handset with the ability to smoothly control the mount and point it at a huge database of celestial objects once an initial star alignment routine has been performed. Go-To systems take the hassle out of manually trying to find an object, especially if they are faint, and can do away with using printed star charts. Their databases usually include the Messier and NGC catalogues, and the major planetary bodies. This opens up the sky to novices and allows experienced astronomers to quickly locate and track deep-sky objects



for astrophotography. These days Go-To technology is available on German equatorial and fork mounts both large and small, and can even be found on some altaz systems, including Dobsonians.

How to
Make and use a flats panel

With **Steve Richards**

This easy way of taking flat frames will help your image processing

The finished panel allows you to take flat frames immediately after capturing your image data

TOOLS AND MATERIALS

COMPONENTS
An electroluminescent panel slightly larger than the diameter of your telescope, an inverter module, 12V power supply and power lead.

MATERIALS
Heavy duty 4mm-thick corrugated plastic sheet.

SUNDRIES
Double sided adhesive tape, electrician's tape, masking tape, methylated spirit.

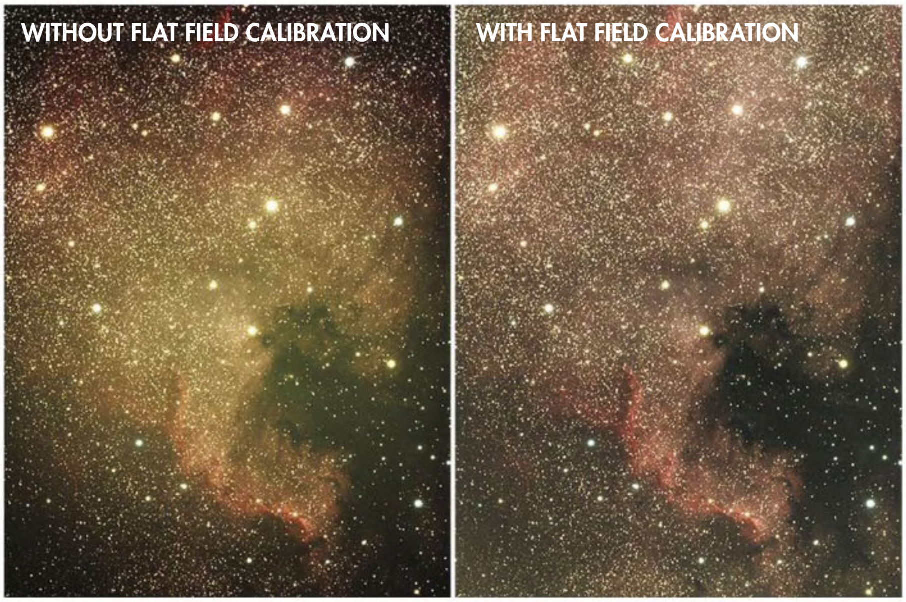
TOOLS
A cutting board, scissors, craft knife, metal straight edge, pencil.

To get the most from deep-sky image data, it is necessary to calibrate your subframes before stacking and processing them into a final image. There are three types of calibration that can be applied to your images: bias frames to remove signal noise caused by the action of downloading your data, dark frames to remove thermal noise produced when your sensor warms up and flat frames to remove the effects of vignetting and dust motes. Whereas bias and dark frames are simple to capture at any time, flat frames require careful planning and execution, so are often forgotten in the excitement of capturing new images.

A flat frame is a special image taken in such a manner that only a facsimile of the plain light cone passing through the telescope to the camera sensor is captured. A typical way of doing this is to cover the front of the telescope with a white cloth and take a series of images with the telescope pointing at the daytime sky. However, it is vital that the orientation of the camera and focus position are maintained between the capture of the celestial images and the flats, and therein lies the problem – you must not disturb the imaging train until the flats have been captured!

There is a fairly simple solution, though: you can use an electroluminescent panel to provide an evenly distributed light source to produce the illumination and capture your flats during an imaging session.

Electroluminescent panels comprise three components – the panel itself (a thin laminated plastic sheet), a 12V inverter



▲ **The North America Nebula; deep-sky shots can be transformed by flat field calibration**

ALL PICTURES: STEVE RICHARDS

that produces an alternating current in the 120V range and a 12V power source. The panels are available in a range of sizes from A6 to A1; choose one that is slightly larger than the aperture of your telescope to ensure complete coverage.

Securing your panel

Because electroluminescent panels tend to be a little flimsy it should be affixed to a backing board. The ideal material for this is the 4mm-thick corrugated plastic sheet often used for signboards as this material is very light, smoothly finished, moisture-proof and surprisingly strong. By applying masking tape to the rectangular shape of the electroluminescent panel (allowing 40mm over the panel length to comfortably support their notoriously fragile electrical connections) you can cut a very neat backing board to size. The panel can be attached to this backing board using double-sided adhesive tape.

As the electrical connections to these panels are so delicate, it is also worth making a loop in the cable near to where it enters the panel and securing this to the backing board with electrician's tape to act as an emergency strain relief. The inverter module can be fixed to the rear of the backing board with double-sided adhesive tape to act as a 'handle' and ensure that no physical tension is applied to the interconnecting cable.

To capture worthwhile flat frames it is important to get the exposure right. Typically, this means achieving between 30 and 50 per cent of the full well capacity (saturation level) of the sensor elements. With a DSLR, this is easily achieved by setting it to aperture priority (Av) mode and letting it automatically choose the exposure time. Astronomical CCD users can use their capture software to determine the ADU (Analogue Digital Unit) value, which is a measure of the individual pixel values in a CCD image and should be in the range of 20,000 to 30,000 units.

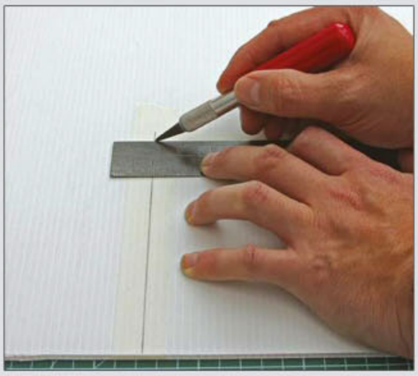
You will need to capture 20 or so subframes, which then need to be stacked to produce a master flat frame using a median combine method. These should then be divided into each image frame to apply the calibration. Many stacking programs, including the freeware DeepSkyStacker, will do this calibration for you. You will be astonished at the improvement in your images.

Steve Richards is a keen astro imager and astronomy equipment expert

STEP-BY-STEP GUIDE

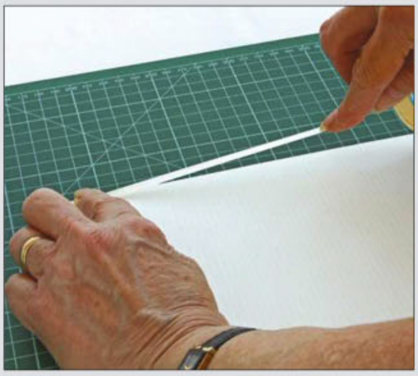
STEP 1

Measure the panel. Mark out the rough size on the plastic sheet in masking tape, adding 40mm to the length. Draw a precise outline (plus 40mm to the length) on the tape in pencil. This extra length will be used to support the panel's electrical connections.



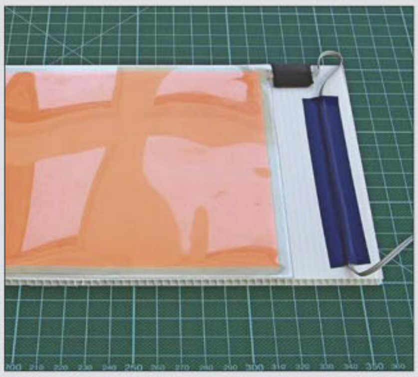
STEP 2

Cut out the rectangle from the plastic sheet. For the best results hold the blade vertically and make several shallow cuts rather than a single deep one. Also note that it is much easier to cut down the web of the sheet than across it.



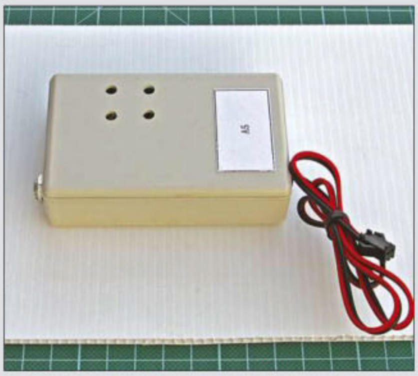
STEP 3

Add a new strip of masking tape to mark the true length of electroluminescent panel, then remove all other tape. Clean the sheet and rear of the panel with methylated spirit. Once evaporated, apply double-sided tape around the perimeter and on the masking tape.



STEP 4

Apply a strip of double-sided tape to the panel's electrical connection. Now fix the panel to the tape applied in Step 3, ensuring that the 'pink' side is uppermost. Form a small loop in the wiring and secure to the board with electrician's tape.



STEP 5

Turn the panel over and clean the rear of the sheet and the base of the inverter with methylated spirit. Once evaporated, apply double-sided tape to the base of the inverter module and fix it firmly to the back of the plastic sheet.

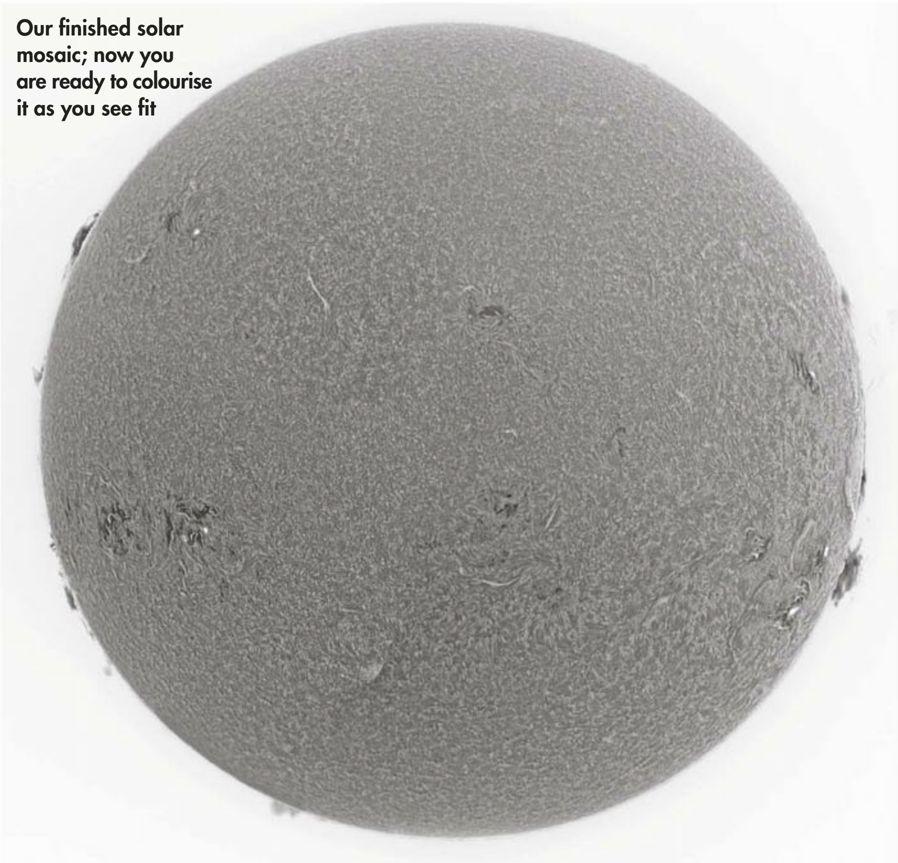
STEP 6

Connect the inverter to the panel and power supply to turn it on. Hold the panel gently over the front of the telescope, ensuring that it is central over the aperture and capture a set of 20 exposures in readiness for producing a master flat to apply to your images.

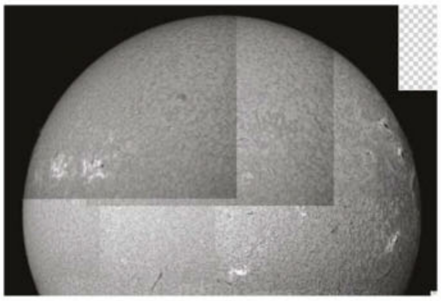
Image processing

Solar mosaics: blending PART 2

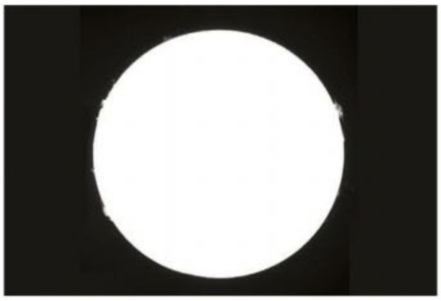
With **Gary Palmer**



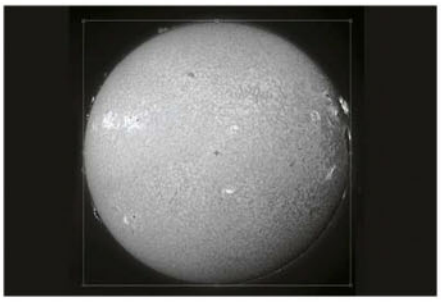
Our finished solar mosaic; now you are ready to colourise it as you see fit



▲ The contrast between panes is likely to differ, but you can fix this with the Levels tool



▲ For the best results, you should align the prominence panes manually



▲ You'll need to use a free transform to fit the surface layer inside the prominence one

Last month we explained how to stack your solar captures; this month we're going to turn them into a mosaic.

Once all the images have been run through RegiStax you need to crop any stack lines from them – we'd recommend using the freeware Faststone Image Viewer (**www.faststone.org**) to do this. Crop each frame to leave neat edges. If you used different settings for your images of the Sun's surface and its prominences, put them in separate folders.

Open Photoshop and click **File** > **Scripts** > **Load Files into Stack**. Select all of your mosaic surface images from the folder they have been saved in, and check the box to align images automatically. This process can take some time depending on the speed of your computer, but once complete you should have the mosaic all aligned with each image on a separate layer.

Next we need to adjust each layer with the Levels tool, as one of the problems with creating large solar mosaics is the difference in contrast between panes. Select each layer and click the Levels icon in the Image Adjustments palette. Adjust the middle slider on each pane to get the contrast as balanced as possible; once you are happy click **Select** > **All Layers**, then **Edit** > **Auto Blend Layers**. When the process has finished you might see some staggered lines – don't worry about them. Right click on the layers and select **Flatten Image**. The image should now be complete, with no lines, ready for you to adjust sharpness and contrast.

For best results with the prominence images, align them manually. Open a prominence image in a new Photoshop window. Click **Image** > **Canvas Size**, select percentage, then type 400 for horizontal and vertical. Now you can drag and drop each prominence pane in to create the complete ring. As before, you will need to adjust the Levels to match the contrast between layers. Once done, select all the layers, auto blend and flatten as above.

Now we'll add the two together. Go back to your surface image and select the Magic Wand tool (set tolerance to 10). Click **Select** > **Inverse** and copy the selection, then return to the prominence image and paste it in. The surface layer will be slight smaller than the prominence one. To adjust, select the surface layer and click **Edit** > **Free Transform**. Drag the image by the corners to fit the prominence ring. When you are happy, click the tick in the title bar. Right click on the layers and select Flatten to finish.

Gary Palmer is an expert solar imager. See more of his shots at www.solarsystemimaging.co.uk

ALL PICTURES: GARY PALMER

TREATING PROSTATE CANCER QUESTIONS & ANSWERS

For a **FREE** copy of this booklet please contact us at the address below.

This booklet has two aims:

- to help you become better informed about prostate cancer and its treatment.
- to guide you in the decisions you will make about your care with your doctor.

It cannot replace talking to your GP or hospital doctor.

Symptoms of prostate problems

Listed below are some of the symptoms which are usually caused by benign disease, not prostate cancer. So do not worry if you have any of these symptoms but go to your doctor to have them checked.

- Difficulty or pain in passing urine.
- Having to rush to the toilet to pass urine.
- Frequent visits to the toilet, especially at night.
- Starting and stopping while urinating.
- Dribbling urine.
- A feeling of not having emptied the bladder fully.
- Blood in your urine.

If you can help us by raising funds for our research or to make a donation please contact us at the address below.

Your support is vital!

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Scope DOCTOR

With **Steve Richards**

Our resident equipment specialist cures your optical ailments and technical maladies

With a budget of £1,500, I'm trying to decide on a scope for my roll-top roof observatory. I'm torn between a Celestron 9.25 Schmidt-Cassegrain or a Sky-Watcher 250-300 Newtonian. Can you advise?

ADAM DELMAGE

There are several pros and cons for both Schmidt-Cassegrains and Newtonian telescopes, but in a observatory there is one key issue: the position of the eyepiece holder on a Newtonian reflector when it is installed on a pier.

This is an important consideration because the height of the observatory walls will dictate how high you need the pier to make sure you are able to observe close to the horizon with your chosen telescope. The higher the pier, the greater the risk of having to use a stepladder, a high seat or even stand on tip-toes when observing objects near the zenith with a Newtonian like the Sky-Watcher ones you mention. From direct experience with a Sky-Watcher 250, a Newtonian can be a disadvantage in an observatory environment, and a Schmidt-Cassegrain like the Celestron 9.25 would avoid this problem.

It would be possible to mitigate some of the issues using a Newtonian by adding weight to the front of the telescope, thus allowing the telescope tube to be moved down the tube rings a little. However, a telescope of this size already requires a heavy duty mount, even without this additional weight, and this would put your budget under pressure for a less than satisfactory solution.

A pier mounted Sky-Watcher 250 will take up a lot of room in an observatory

STEVE'S TOP TIP

Do I need to keep a log book?

Keeping a log book for your astronomical observations is a great idea as this serves two fundamental purposes. A log book records your personal achievements and if you annotate it with thumbnail sketches and minor comments it makes for a great, even sentimental read in the future. Just as importantly though, if you document your findings accurately your observations can contribute to real science, not only for comparing with your own previous findings but for adding to the general knowledge base of professional astronomers and researchers – especially for unusual sightings such as comets, meteors, fireballs, novae and aurorae.

I have a Sony H300 digital bridge camera, but I'm having trouble connecting it to my telescope. Do you have any advice?

WARREN BROWN

The 365Astronomy Digital Camera Microstage Adaptor may hold a bridge camera

Bridge cameras aren't particularly suitable for astrophotography as their large physical diameter lenses are not interchangeable, but they can be pressed into service for afocal imaging. This is where you hold the camera up against the telescope's eyepiece, rather than the usual method of attaching a camera body (without lens) directly to the telescope's focuser, which is called prime focus imaging. The problem with afocal imaging with this type of camera is that the large lens diameter produces a 'port hole' view of the night sky!

There are several adaptors that support ordinary compact digital cameras but these are mainly unsuitable for bridge cameras. However, the 365Astronomy Digital Camera Microstage Adaptor for Telescopes or the Baader MicroStage II Clickstop Digital Camera Adaptor both have a wealth of adjustment to help align the camera's lens with the eyepiece and should be able to accommodate the Sony H300.

Steve Richards is a keen astro imager and an astronomy equipment expert

Email your queries to scopedoctor@skyatnightmagazine.com

Sky at Night MAGAZINE

Reviews

Bringing you the best in equipment and accessories each month, as reviewed by our team of astro experts

HOW WE RATE

Each category is given a mark out of five stars according to how well it performs. The ratings are:

★★★★★ Outstanding
★★★★★ Very good
★★★★★ Good
★★★★★ Average
★★★★★ Poor/Avoid

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90

How the Paramount MYT mount combines precision with portability

This month's reviews

Find out more about how we review equipment at: **www.skyatnightmagazine.com/scoring-categories**

WWW.THESECRETSTUDIO.NET X 4

FIRST **light**

See an interactive 360° model of this mount at
www.skyatnightmagazine.com/ParaMYT

Software Bisque Paramount MYT mount

A high precision portable mount that justifies its hefty price tag

WORDS: PETE LAWRENCE

VITAL STATS

- **Price** Mount £4,998; Berlebach Planet tripod £498 (reduced to £398 if purchased with the MYT)
- **Load capacity** 23kg equipment, 46kg including counterweights
- **Software** TheSkyX Professional with TPoint add-on (compatible with Windows and OSx)
- **Database** 1.2 million stars and thousands of deep-sky objects; database add-on available using the NOMAD catalogue
- **Weight** Mount 15kg excluding counterweight and shaft; Berlebach tripod 11kg
- **Supplier** Ian King Imaging
- **www.**iankingimaging.com
- **Tel** 01580 212356

WWW.THESECRETSTUDIO.NET X 4, PETE LAWRENCE X 2

Paramount robotic mounts provide high accuracy pointing and tracking platforms. This comes from a synergy of precision engineering working with Paramount's fourth generation MKS-5000 computerised control system. Where the larger mounts in the Paramount range are designed for permanent or semi-permanent installations, the MYT (pronounced 'mighty') is offered as a portable grab and go mount. Initially, this seems at odds with the precision that Paramount robotic mounts are so well known for.

The MYT's £5,000 price tag includes the mount head, cables, 9kg counterweight, control handset and control software, but you have to supply something for it to sit on. We used the wooden Berlebach Planet tripod (£498; £398 if purchased with the MYT), offering strength, excellent vibration damping and low weight. Visually, the MYT on the Berlebach tripod would definitely be a head turner at a star party.

Both components are easy to lift even when assembled. The tripod's load limit is in excess of 80kg, making it a comfortable match for the MYT's 23kg capacity or 46kg including counterweights. The MYT's capacity is lower than larger Paramount models but still pretty generous, especially considering portable setups. The mount's MKS-5000 controller connects to a computer via a USB cable; a supplied copy of Software Bisque's TheSkyX planetarium software provides the user interface.

SKY SAYS...
£5,000 is a lot of money for a portable mount, but the ease of setup and benefits are worth it

The MYT's aluminium body is solid and attractively finished. Rough polar axis elevation is performed by moving a bar in a set of slots machined into the body. A latitude adjuster wheel provides fine tuning. In use, it was necessary to select the slots carefully because in some positions the bar slipped out while turning the adjuster.

A meaty 48V (80W) power supply plugs into a panel called the 'electronics box'. This also incorporates the ports for the USB connection and handset. The handset itself is a solid affair with a thumb stick and four-speed selector. It feels very natural to use. Optional battery packs are also available to maintain portability.

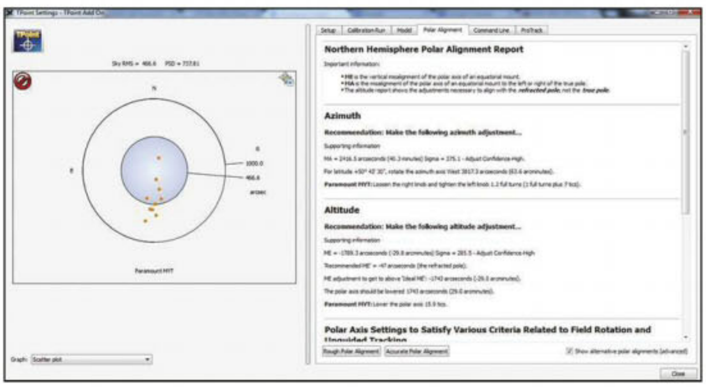
Novel polar alignment

The mount has no polar alignment scope but thanks to some clever software, getting everything aligned is very easy to do. TheSkyX includes an integrated version of its TPoint add-on. This provides instructions to roughly align the mount. Next, you need to compare TPoint's idea of where things are in the sky to where they actually are.

Once we'd set everything up, we first homed the mount. This gives the controller a start reference ▸

INCREDIBLE POINTING ACCURACY

Coupling excellent engineering with advanced pointing models via TheSkyX's integrated TPoint add-on gives the portable MYT the capability to exhibit impressive pointing accuracy. To maintain this level of accuracy, the MYT will only track for a maximum of two hours past the meridian. After this, a meridian flip is required. The TPoint model is further enhanced by an option called 'Super Model'. This analyses the TPoint data and statistically optimises it to provide an even more precise pointing model. A 'ProTrack' software feature can be used to eliminate errors from physical effects such as refraction and flexure. These are the same pointing corrections used on large professional telescopes. With a good number of pointing samples supplied manually or via automated camera routines, the software models will confidently centre celestial objects selected from TheSkyX's database, and up to 1,200-second unguided exposures.



▲ The TPoint add-on's many uses include getting the MYT polar aligned

BALANCE/TRACKING SELECTORS

The RA and dec. axes both have balance/tracking selector switches. Both can also be position locked for transportation. While balancing, an axis swings freely so it's necessary to hold your kit carefully in case your initial balance is even slightly off. This setting is excellent for getting precise and accurate balance.

VERSA-PLATE

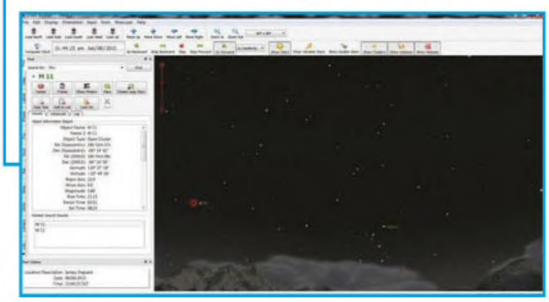
Telescopes attach via the 'Versa-Plate' which natively accepts Losmandy and Celestron dovetails. Wires from power and USB couplings on the 'electronics box', feed up through the mount to an instrument panel at one end of the Versa-Plate. Cameras, focusers and other equipment can be directly connected to the USB, autoguider and 5V/12V ports.

BERLEBACH PLANET TRIPOD

We used a Berlebach Planet tripod to support the MYT. Made from ash, this has excellent vibration damping characteristics and a load capacity of more than 80kg. Its height range is 90-138cm and the legs are ruled to let you know how far they have been extended.

THESKYX AND TPOINT

TheSkyX Professional is a feature-rich planetarium and equipment control program. It controls the position of the MYT with great precision and can operate other equipment such as cameras. It comes with the Camera and TPoint add-ons; the latter allows you to convert the MYT's rough alignment model to one with impressive pointing and tracking accuracy.



FIRST **light**

SKY SAYS…
Now add these:

1. Counterweight shaft extender
2. Wi-Sky MKS-5000 Wi-Fi control
3. Altair RC250-TT astrograph

ALTITUDE AND AZIMUTH ADJUSTERS

Altitude and azimuth adjusters play a big role in rough aligning the mount. TPoint can suggest how many turns of these adjusters will refine polar alignment accuracy. Designed for use between 0-64° latitude, altitude adjustment slots allow you to get in the right ball park for fine tuning polar altitude alignment.

▸ and identifies whether you've put the telescope on the right way round. TPoint is taught how well the mount is aligned by slewing to an object in TheSkyX and adjusting the telescope, via the handset, to centre the object. Once done, this pointing sample is added to TPoint's sky model database.

For a portable mount, this must be done with every setup. We found that given six pointing samples, anything we slewed to via TheSkyX would be centred correctly. Camera exposures up to 60 seconds were fine, but anything longer showed trailing. With 25 points defined, unguided exposures of 300 seconds amazingly showed little sign of trailing. Increasing the count further takes you closer to the quoted unguided maximum of 1,200 seconds (20 minutes) – a seriously impressive figure for any mount, portable or not. Autoguiding and Software Bisque's DirectDrive guiding, which connects directly to the mount controller, are also supported should you need them.

If you don't fancy working through lots of pointing samples manually and have a camera attached, facility is provided to automate the process. Here, TheSkyX slews to selected targets, takes a photo via the included Camera add-on, and works out where it's looking. This process can produce more than 100 samples per hour, leading to a highly accurate sky model.

From initially uneasy feelings about the marriage of high precision and portability, the MYT proved itself spectacularly. It's true that £5,000 is a lot of money for a portable mount, but the ease of setup and benefits it brings are definitely worth it. Of course, there's nothing to stop you from buying the MYT and setting it up as a semi-permanent or even permanent mount. If this is done the TPoint model remains valid even after the mount is turned off, giving you superb accuracy night after night. Ⓢ

VERDICT

ASSEMBLY	★★★★☆
BUILD & DESIGN	★★★★☆
EASE OF USE	★★★★☆
GO-TO ACCURACY	★★★★★
STABILITY	★★★★★
OVERALL	★★★★★

WWW.THESECRETSTUDIO.NET

FIRST **light**

See an interactive 360° model of this scope at
www.skyatnightmagazine.com/LW66EDR

Altair Astro Lightwave 66ED-R refractor

A small scope in a basic package, but one with huge potential

WORDS: PAUL MONEY

VITAL STATS

- **Price** £329
- **Aperture** 66mm (2.59 inches)
- **Focal length** 400mm (f/6)
- **Optics** Doublet with air-spaced Ohara ED glass
- **Tube length** 305mm dewshield retracted (370mm extended)
- **Focuser** 2-inch dual-speed rack and pinion
- **Weight** 2kg
- **Extras** Retractable dew shield, hard aluminium carry case, 2- to 1.25-inch adaptor with brass compression rings
- **Supplier** Altair Astro
- **www.**altairastro.com
- **Tel** 01263 731505

WWW.THESECRETSTUDIO.NET X 5, PAUL MONEY

SKY SAYS…
A small, yet versatile refractor that can act as a grab and go, wide-field visual or imaging scope.

Small refractors such as Altair's Lightwave 66ED-R may give the impression that you won't get to see much due to their diminutive size, but don't let that fool you. Instruments like this one perform far better than the classic 60mm achromats that beginners traditionally start off with. As we discovered, the Lightwave 66ED-R packs some punch.

This refractor is supplied as a basic package comprising only the telescope tube, which is fitted with a 2-inch dual-speed rack and pinion focuser (this is what the R stands for in ED-R), a retractable dew shield, hard aluminium carry case and a 2- to 1.25-inch adaptor with brass compression rings. For visual use you will need to add a star diagonal and a selection of eyepieces; for DSLR astrophotography, you will also need a T-ring and nosepiece.

We used our own dielectric star diagonal, 26mm and 10mm eyepieces, plus 2x Barlow and 5x Powermate lenses for our tests. Viewing the bright star Regulus in Leo with the 26mm eyepiece gave a magnification of 15x and a wide field of view covering just over 3°. This meant that when we turned to the constellation of Lyra, the Harp, we could fit both Beta and Gamma Lyrae in the view with room to spare. The viewing quality was good, with Regulus pin sharp across 90 per cent of the field and only a slight degradation towards the field edge. Colour aberration was also well controlled, with only the slightest fringing on bright stars when the magnification was pushed beyond 100x.

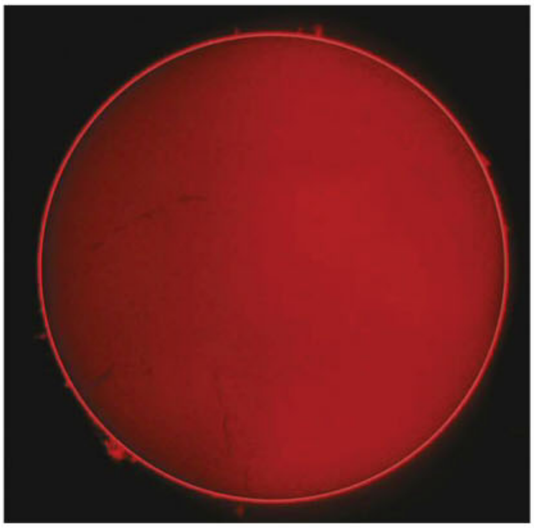
Pushing the magnification

Altair Astro suggests that the theoretical maximum magnification is 133x using a 3mm eyepiece, however using a 10mm eyepiece and 5x Powermate to give the equivalent of a 2mm eyepiece (200x magnification) we could split Epsilon Lyrae, the 'Double Double', into its four constituent stars and the view was just acceptable. Indeed double stars were a treat in this scope and there is a huge range of them within its reach, including Albireo (Beta Cygni), 17 Cygni and Nu Draconis. With low magnification many will look like a single star, but push the magnification up and you will be rewarded with great views.

Deep-sky observing is a mixed bag due to the wide field of view at low magnification, but using a 26mm eyepiece we could spot most of the brighter deep-sky objects in the Messier and Caldwell catalogues. The galaxy pair of M81 and M82 in Ursa Major were lovely smudges, with the thin, side-on view of M82 apparent. Adding our 2x Barlow improved the view. ▸

SOLAR SCOPE POTENTIAL

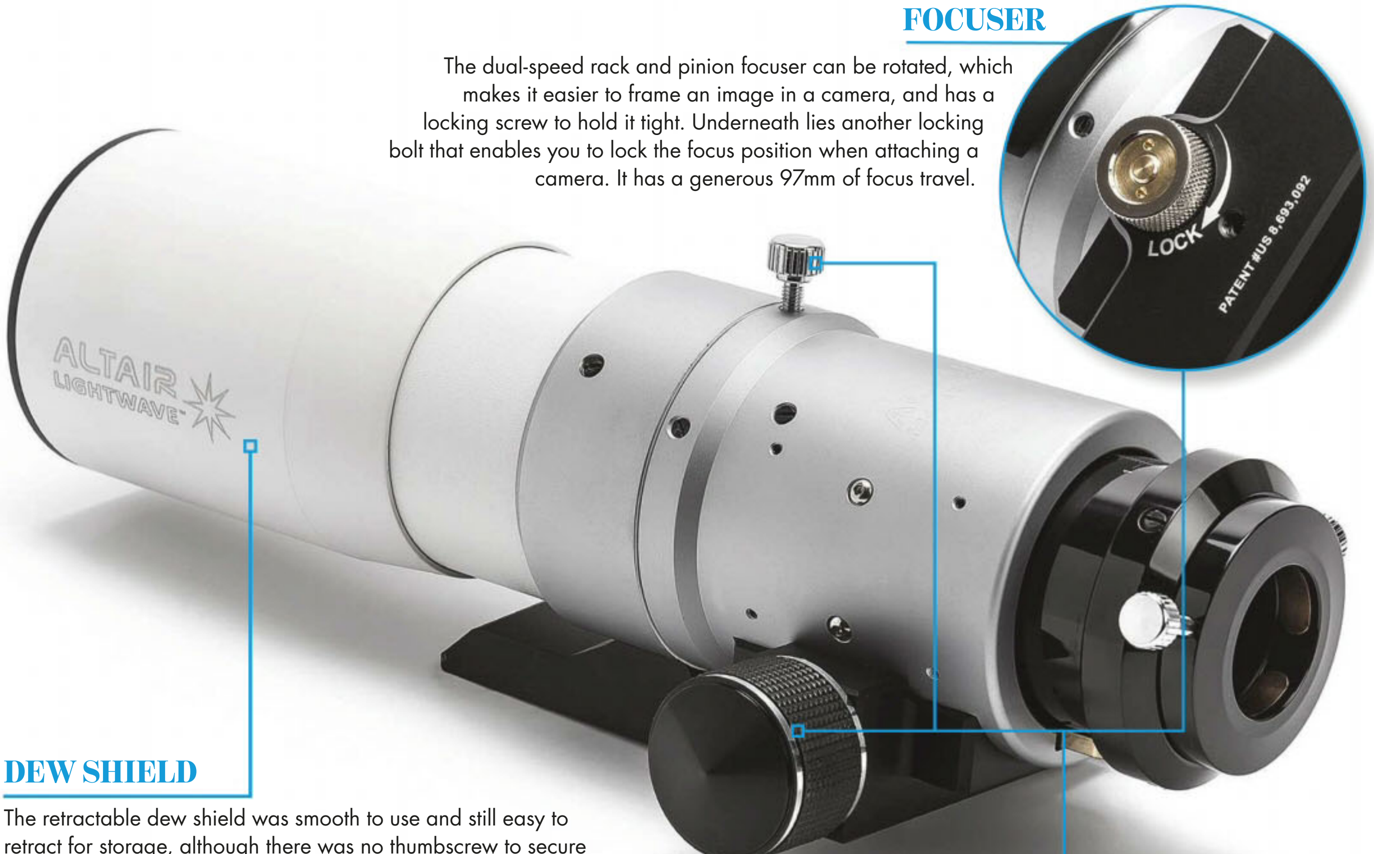
The Lightwave 66ED-R is a good all-rounder and ideal for grab and go observing. However, beyond the night sky, this scope could be used with a DayStar Quark eyepiece filter to view the Sun in hydrogen-alpha light. Being a small instrument, the 66ED-R does not require an energy rejection filter – they are only needed for instruments with a lens diameter larger than 3 inches. We were able to borrow a Quark Chromosphere eyepiece filter and used it with the 66ED-R for both observing and imaging: it gave impressive views of our star. With our 26mm eyepiece inserted we could view the whole of the solar disc, including prominences and surface detail. It is yet another string to the bow of this versatile instrument.



▲ **Solar close-up with a DayStar Quark Chromosphere eyepiece filter fitted; this is a composite of two images**

FOCUSER

The dual-speed rack and pinion focuser can be rotated, which makes it easier to frame an image in a camera, and has a locking screw to hold it tight. Underneath lies another locking bolt that enables you to lock the focus position when attaching a camera. It has a generous 97mm of focus travel.



DEW SHIELD

The retractable dew shield was smooth to use and still easy to retract for storage, although there was no thumbscrew to secure it in place. However, friction appeared to keep the dew shield extended throughout our review period, and it gave good protection from dewing up under slightly damp conditions.

MOUNTING

The Lightwave 66ED-R has an L-shaped mounting bracket consisting of a dovetail-style foot to fit most telescope mounts with Synta- or Vixen-style mount heads. Under the base there is also a 1/4-inch photo tripod thread for fixing the telescope to a standard photographic tripod.

INTERNAL BAFFLES

Internal reflections can spoil the contrast in faint deep-sky objects, so it is good to see the internal baffles and inner tube surface are matt coated to cut down on any stray light bouncing around inside the tube.

FIRST light

OPTICS

The 66mm, f/6 optics are a doublet arrangement composed of Ohara ED (extra-low dispersion) glass elements, giving good colour correction. All air-facing surfaces are coated with super-high transmission coatings, which helps to improve contrast.

SKY SAYS...
Now add these:

1. DayStar Quark eyepiece filter

2. iOptron iEQ30 Pro mount

3: Altair Lightwave dielectric diagonal

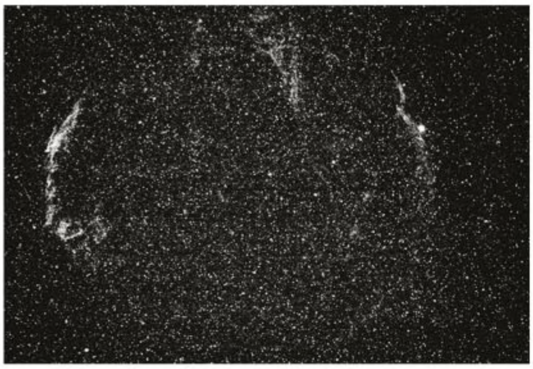
▸ Large objects such as Melotte 111 in Coma Berenices and the Beehive Cluster in Cancer fared better at low magnification, giving pleasing views. The star fields of Scutum were just coming into view for us and we did enjoy sweeping the Milky Way when we attached the scope to a photo tripod for ease of use.

Due to the wide field of view, the Moon and planets appeared small through the 26mm eyepiece, but due to the quality of the optics we could push the magnification to explore the cratered landscape of the Moon and spot the two main belts on Jupiter, along with the four Galilean moons. Despite being small, Saturn was crisp, and again high magnification allowed us to glimpse the Cassini Division, a hint of a belt on the planet and several of its brighter moons.

Attaching our modified Canon EOS 300D DSLR with its APS-C sized sensor allowed us to image the nebulosity around the star Sadr in Cygnus. We took 22 images, each exposure lasting two minutes, at ISO 800, then stacked and processed them to bring out the nebulosity. The results were pleasing, but did show the typical effect of distorted stars towards the field edges. A field flattener would be useful for wide field imaging – adding one of our own, plus a hydrogen-alpha filter, revealed sharp stars to the edges in an image of the Veil Nebula Complex.

The Lightwave 66ED-R is a small, yet versatile refractor that can act as a grab and go, wide-field visual or imaging scope, or even be pressed into service as a guidescope or for viewing the Sun in hydrogen-alpha light.

▸ **Sadr in Cygnus plus its nebulosity; 22 two-minute exposures at ISO 800**



▸ **The Veil Nebula Complex in hydrogen-alpha with field-flattener; eight two-minute exposures at ISO 2000**

WWW.THESECRETSTUDIO.NET, PAUL MONEY X 2

VERDICT

BUILD & DESIGN	★★★★☆
EASE OF USE	★★★★★
FEATURES	★★★★☆
IMAGING QUALITY	★★★★☆
OPTICS	★★★★☆
OVERALL	★★★★☆

FIRST **light**

See an interactive 360° model of this camera at
www.skyatnightmagazine.com/ASI174MM

ZWO ASI174MM mono high frame rate camera

Blistering frame rates make this all-round camera something rather special

WORDS: PETE LAWRENCE

VITAL STATS

- **Price** £549
- **Sensor** Sony IMX174LLJ (CMOS), 1/1.2-inch (13.4mm diagonal)
- **Pixel array** 1,936x1,216 pixels, (5.86μm square)
- **Exposure range** 32 microseconds to 1,000 seconds
- **Frame rates** (10-bit/12-bit) 164/128fps at 1,936x1,216; 397/309fps at 640x480
- **Size** 62mm diameter, 41mm deep
- **Weight** 140g
- **Supplier** 365Astronomy
- **www.**365astronomy.com
- **Tel:** 020 3384 5187

WWW.THESECRETSTUDIO.NET X 4, PETE LAWRENCE X 2

The ASI174MM is a monochrome high frame rate camera. It's a USB 3.0 device, capable of some blisteringly fast frame rates. What's exceptional about it is that it can achieve these rates using the whole of the sensor but, with a full array of 1,936x1,216 pixels, you'd better make sure there's plenty of free space on your hard drive.

The peak delivery rate is determined by the exposure time, the size of the pixel array and the bit-depth of the image being captured. Like many modern high frame rate cameras, it's possible to create a 'region of interest' on the chip. When this is active, only the pixels within the region of interest are used. This reduces the amount of data sent down the connection port and provides the opportunity for the camera's frame rate to go even higher.

At full frame, the ASI174MM can deliver 128 frames per second (fps) in its 12-bit mode and 164fps in 10-bit mode. The number of bits of a pixel determines how many grey tones it can represent and is equal to two to the power of the bit-depth: 10-bits give 1,024 tones and 12-bits give 4,096 tones. In theory, the higher bit-depth should give greater tonal fidelity to the final result. To be honest, for a lot of subjects, the difference isn't that obvious.

SKY SAYS...
Its forte is making spectacular, large-area captures of bright objects such as the Sun and Moon

Frame rate is important when imaging Solar System objects because the fine detail they present can be badly affected by Earth's turbulent atmosphere. Recording lots of still frames in rapid succession increases the chances of capturing the fleetingly short periods of good seeing that occur. Freeware applications such as RegiStax and AutoStakkert! can then be used to extract, align and average those images to produce a smooth, distortion-free end result.

Mosaics made easier

The high frame rate means that the camera can fill a hard drive very quickly and from our experience, a minimum 100GB of free space is recommended per session. The ASI174MM is perfectly matched to capturing large, extended targets such as the Sun and Moon, and removes a huge amount of work ▸

▲ This lunar mosaic is comprised of 22 panes; each 1,936x 1,216-pixel frame was captured at an average 128fps

MAKING THE FRAME RATE WORK FOR YOU

The ASI174MM deserves the high frame rate title. However, you need to pay attention to the settings to get the best out of it. A fast USB 3.0 computer, preferably with a solid state drive, is also required for best performance.

We reached the top frame rate of 164 frames per second (fps) full frame, while imaging the bright Sun and Moon. However, our 1,000-frame test captures resulted in an average fps drop as our laptop's 5,600rpm hard drive struggled to keep up. This camera was superb for capturing large areas of bright targets, even considering the reduced averages achieved.

For the planets, the 1,936x1,216 is overkill, so we used a region of interest to reduce data overhead. Here, frame rate is more limited by the sensitivity of the chip and exposure used. For example, using a 9 millisecond exposure on Jupiter limited our frames per second to the number of 9 millisecond intervals there are in 1 second – in this case, 111. On a bright planet like Venus, we managed to achieve nearly 400fps using the same setup because we could use a shorter exposure.

AUTOGUIDER PORT

This versatile camera provides an ST-4 compatible autoguider port. For deep-sky imaging, the ASI174MM can be inserted into a guidescope and connected to a suitable mount by a supplied 2m cable. An ASCOM driver is available from the ZWO website, allowing the camera to be used by programs such as the popular PHD autoguiding software.

CAMERA BODY

The ASI174MM's aluminium body produces a lightweight 140g device. Two connection ports are provided: one for USB 3.0 and one for autoguiding. The main opening is a low profile 2-inch barrel, internally T-threaded (M42x0.75). A 1.25-inch adaptor is supplied as standard. A standard tripod threaded hole is provided at the rear of the camera.

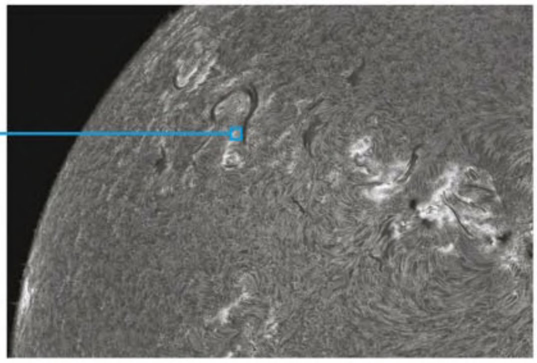


IMAGE QUALITY

The Sony IMX174LLJ sensor has a low read noise (6e/15e in low/high speed modes) with a quantum efficiency of 78 per cent, peaking around 500nm (blue-green). It also has no fixed pattern noise, an effect that can produce unwanted regular patterns in images. Consequently, the processed results are excellent quality.

SENSOR

The camera uses a 1/1.2-inch (13.4mm) CMOS Sony IMX174LLJ sensor, offering 1,936x1,216 pixels each 5.86μm square. The chip uses a global shutter, so avoiding unwanted motion distortion. Regions of interest are supported, as well as a 2x2 binning mode for high sensitivity applications. The sensor is mounted behind an anti-reflection coated optical window.

FIRST **light**

USB 3.0 PORT

The ASI174MM requires a USB 3.0 connection for full-speed operation. It can be connected to a USB 2.0 port but full frame capture rates drop to around 18fps. The supplied 2m cable has a USB 3.0 type A plug for the computer connection and a USB 3.0 type B plug on the camera end.

SKY SAYS...
Now add these:

1. ZWO five-position filter wheel with 1.25-inch eyepiece holder

2. ZWO 1.25-inch CCD LRGB filter set

3. ZWO 60mm finder and guidescope with non-rotating helical focuser

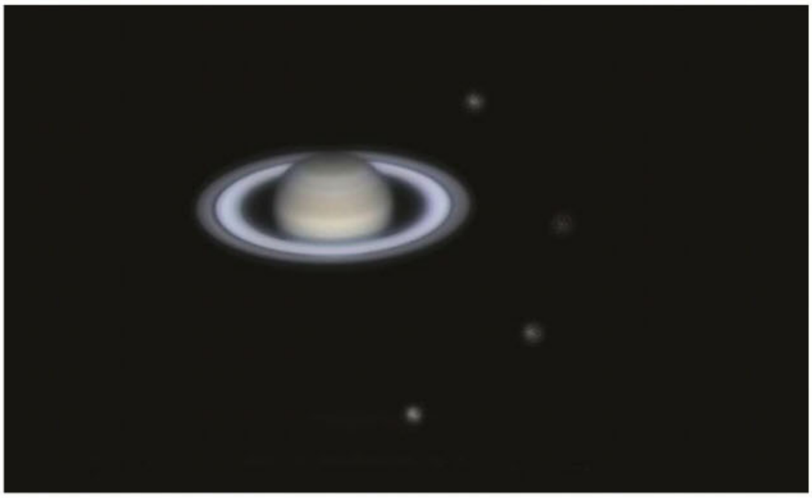
▸ when producing mosaics. Using a Celestron C14 telescope (14-inch aperture, f/11) at prime focus, we were able to create a mosaic of an 84%-lit Moon using just 22 panes. The end result was just over 6,000 pixels square. At the other end of the spectrum, an ED80-style scope (3-inch aperture, f/7.5) could easily produce a full disc image of the Sun on the camera's chip.

For the planets, the full sensor area is less important unless you want, for example, to create a family portrait of Jupiter or Saturn with their moons. For disc-only shots the region of interest comes into its own, with a much smaller area on the chip being used to record just the planet's disc.

As well as its amazing Solar System imaging capabilities, the ASI174MM can also be used for deep-sky imaging too. Its capabilities here are quite respectable due to the chip's low noise. You won't match the output from a dedicated cooled CCD camera, but you can still get decent results. Just to add further value to its capabilities, the camera is also equipped with an ST-4 compatible autoguiding port, allowing you to use it as a guide camera.

The ASI174MM comes with a set of drivers and basic control software. However, we'd recommend downloading the latest drivers from the ZWO website. Similarly, the most common control software used is the freeware FireCapture, which standardises the control interface for a variety of cameras.

This is a fantastic all-round camera capable of imaging Solar System objects as well as deep-sky targets. Its forte is producing spectacular, large-area captures of bright objects such as the Sun and Moon. Although other cameras, including earlier cameras from ZWO themselves, have encroached on this capability, the amazing frame rate offered by the ASI174MM makes it a first-class performer for this sort of application. Ⓢ



▾ **Saturn's family portrait; this is a composite of five 640x480-pixel IR-RGB shots of the planet and two 1,936x1,216 shots for the moons**

VERDICT

BUILD & DESIGN	★★★★★
CONNECTIVITY	★★★★★
EASE OF USE	★★★★★
FEATURES	★★★★☆
IMAGING QUALITY	★★★★★
OVERALL	★★★★★

WWW.THESECRETSTUDIO.NET, PETE LAWRENCE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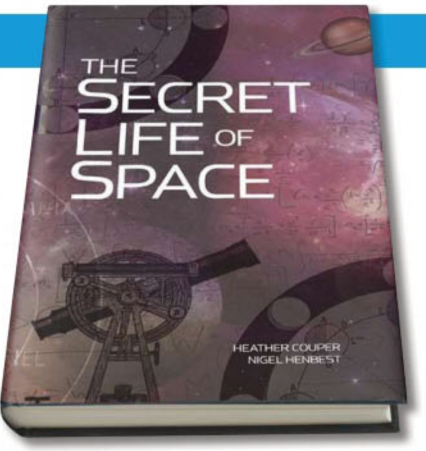
Books

New astronomy and space titles reviewed

RATINGS

★★★★★ Outstanding
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor
★☆☆☆☆ Avoid

You can order these books from our shop by calling 01803 865913



The Secret Life of Space

Heather Couper and Nigel Henbest
Aurum Press
£20 ● HB

The Secret Life of Space is a non-stop tour of all the big moments in the history of Western astronomy. Ptolemy is there, as are Newton, Hubble and Einstein. For students of astronomy it's a great introduction to major stories, revealing the personalities behind the names known otherwise as those of satellites, theorems and equations. There are lesser-known inclusions too, such as the Antikythera mechanism from Ancient Greece, and there is a strong emphasis on 20th and 21st Century astronomy. My problem, however, is with the book's opening claim: that it seeks to uncover and debunk old myths regarding astronomy's history. It even goes so far as to assert that it is about the "unsung heroes and heroines" and that it includes the many overlooked but "important breakthroughs [that] have been made by women". This is an excellent and laudable aim; sadly it is not followed through.

This book, with a few minor additions, is a retelling of the same 'great men' story of astronomy's history that has been told for decades. It's a shame, because it would have been perfectly possible to deliver on the more ambitious claims. The past 30 years have seen some fantastic research rediscovering lost women and returning the technicians, assistants and other generally lower class contributors to the story. There has been a surge too in interest and research regarding the contributions to science that took place outside America and Europe, particularly in the Islamic world and in China. All this historical research, however, is ignored. Women in this story are overwhelmingly cheerleaders, on the periphery of great (male) achievements, while non-Western cultures are seen as 'exotic'.

Ptolemy explains astronomy to Johannes Müller

ISTOCK

If we put aside the opening claims of this book and an unfortunate dig at environmentalists at the beginning of chapter eight, however, it is still an entertaining read, and does give a certain historical backdrop to the many names that populate modern astronomy. And when all is said and done, a book that lets us know Fritz Zwicky used to refer to his disliked colleagues as 'spherical bastards' can't be all bad.
★★★☆☆

EMILY WINTERBURN *is the author of* Stargazer's Guide

Reader price £18.99, subscriber price £17.99
P&P £1.99 Code: S0815/1 (until 21/09/15)

TWO MINUTES WITH NIGEL HENBEST

What inspired you to write this book?
The discovery of the Universe is too often presented as a dry list of discoveries and facts. We wanted to unearth the personalities of the people who unravelled the mysteries of the cosmos.

What's the most surprising secret you found when writing the book?
That Stonehenge was built to celebrate the winter solstice, not Midsummer's day! Remains of huge feasts nearby, which attracted people from all over the country, contain the bones and teeth of pigs that were nine months old when slaughtered (and piglets are naturally born in the spring).

Are there any particularly persistent myths that need debunking?
That Galileo invented the telescope and first used it to observe the sky. Hans Lippershey, lucky enough to have a local source of superb quality glass for his lenses, applied for a patent on the telescope as early as 1608, and a contemporary Dutch pamphlet reveals that "even the stars which are ordinarily invisible to our sight ... can be seen by means of this instrument". Galileo later heard about the 'Dutch trunke', and copied it.

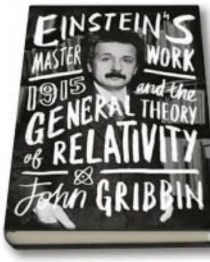
What is the biggest question left in space science?
What makes up the dark matter and dark energy that controls the Universe?

NIGEL HENBEST *is a science populariser, specialising in astronomy and space, and has recently been appointed honorary professor at the University of Dundee*

Einstein's Masterwork

1915 and the General Theory of Relativity

John Gribbin
Icon Books
£10.99 ● HB



Einstein's Masterwork celebrates the centenary of the publication of Albert Einstein's general theory of relativity. Einstein had published his special theory in 1905, his work at that time leading to the equation E=mc² which, as the author points out, is the only equation that everybody knows. Consequently, the special theory is held by many to represent the pinnacle of Einstein's achievements.

However, this book suggests that Einstein's tour de force was undoubtedly the general theory which, published in 1915, relates to the evolution and expansion of the Universe, the bending of light and gravitational lensing, the Big Bang, black holes, wormholes and even the possibility of time travel. What follows is an informative account of Einstein's work in the preceding 10 years, the period during which the general theory was formulated.

As we discover, Einstein's efforts in this period were set against many difficulties, not least of which was his deteriorating health, culminating in a physical and mental collapse in early-1917 from which he never fully recovered. Indeed, this period in his life took its toll: the book tells us that the illness and wartime privation he endured turned the "dashing dark-haired young man" that was pre-war Einstein into "the white-haired professor that became the image of a scientist".

All in all this is an absorbing and readable account of Einstein's life and work, and the argument that 1915 was indeed his greatest year seems proven.

★★★★★

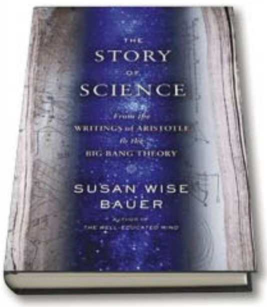
BRIAN JONES *has written 15 books on astronomy and space*

Reader price £9.99, subscriber price £9.50
P&P £1.99 Code: S0815/2 (until 21/09/15)

The Story of Science

BOOK OF THE MONTH

Susan Wise Bauer
WW Norton & Company
£16.99 ● HB



The Story of Science is not a history of science, yet it manages to be a masterly account of the great minds who have helped expand human knowledge, from the earliest philosophers onwards. It focuses on the major players on the scientific stage, and how they communicated their ideas and discoveries.

The result is a volume that not only describes the key moments in scientific history, from ancient Greek thinkers such as Hippocrates and Plato to Stephen Hawking today, but also highlights their important texts and ways we can delve into them. We are told where to find translations of historic works, plus publications that can help us understand them better. Links are also given to pages on the author's own website where more may be learned.

Though the book covers science generally, there is much to interest amateur astronomers – from Ptolemy, whose *Almagest* described an Earth-centred Universe in 150 AD, through to the revolutionary work of Copernicus and then Galileo, Robert Hooke and Isaac Newton in the 16th and 17th Centuries. In more recent times, the contributions of Einstein and Max Planck in the early 20th Century are followed by the works of Edwin Hubble, Fred Hoyle, Steven Weinberg and others in aiding our understanding of the nature of the Universe.

This book is a guide to how scientific knowledge has advanced, but also acts as an invaluable reference to help readers learn more from the people who made it happen.

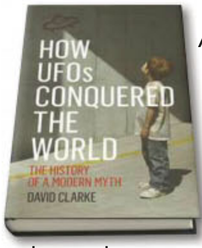
★★★★★

PAUL SUTHERLAND *is a space writer and journalist*

Reader price £15.99, subscriber price £14.99
P&P £1.99 Code: S0815/3 (until 21/09/15)

How UFOs Conquered the World

David Clarke
Aurum Press
£18.99 ● HB



As the introduction makes clear, this book is not about UFOs themselves, but the people who see and believe in them. It examines the rise in the modern UFO myth, distilling decades of detailed research and interviews into a fascinating account.

How UFOs Conquered the World re-examines some of the most famous alleged encounters with extraterrestrials – for example, the sighting made by American Kenneth Arnold that led to the term 'flying saucer' being coined in 1947. Noting that Arnold was describing the movement rather than the shape of whatever he had seen, the book shows how this simple mistake in the original press report influenced many future sightings. It goes on to explore how UFO reports reflected the concerns of the times, the imagery of science fiction and the expectations of the viewer.

The reportage style is both entertaining and informative. Those who believe in the 'extraterrestrial hypothesis' – that some UFOs are indeed spacecraft helmed by aliens – are never ridiculed, even when the sighting turns out to be a hoax. This is rounded off with full references as well as a bibliography and index, making it easy for readers to delve further, should they wish. Indeed, this is a refreshing perspective on a wide range of UFO-related experiences. Don't be put off simply by the word 'UFO' in the title – there is much to recommend within.

★★★★★

MARK BOWYER *is an expert in the US manned space programme*

Reader price £17.99, subscriber price £16.99
P&P £1.99 Code: S0815/4 (until 21/09/15)

Gear

Elizabeth Pearson rounds up the latest astronomical accessories

[redacted]

1 Modern Astrolabe

Price £74 • **Supplier** Columbus Globes
www.columbusglobes.co.uk

For millennia, astrolabes helped astronomers keep track of time and the stars. Now you can own your own, accurate at latitudes of 49-52°. Measures 10cm in diameter.

2 Dark Sky Meter iPhone App

Price £0.79 • **Supplier** DDQ
www.darkskymeter.com

Turn your iPhone into a sky meter for a fraction of the price of a dedicated device. You can also submit your sky brightness readings to the International Dark Sky Association and help keep track of light pollution. Compatible with iPhone 4s and up.

3 ISS Haynes Edition Jigsaw

Price £11.99 • **Supplier** IWOOT
www.iwantoneofthose.com

Recreate the International Space Station with this 1,000-piece jigsaw puzzle. It features a classic illustration in Haynes Manuals styling, along with detailed close-ups and facts.

4 Orion Eight-Slot 1.25-inch Filter Slider

Price £149 • **Supplier** SCS Astro
01823 665510 • www.scsastro.co.uk

This eight-slot filter slider makes it easy to swap between different filters to quickly compare effects while observing, or to speed up taking different wavebands while imaging.

5 Padded Counterweight Bag

Price £19.80 • **Supplier** 365 Astronomy
020 3384 5187 • www.365astronomy.com

Lugging your counterweight around at star parties can be a pain, but with this bag the job is much easier. Fits weights less than 17cm in diameter and 8cm in height.

6 Astronomy Wallhanging

Price £22.50 • **Supplier** House by Betty
07811 185511 • www.housebybetty.com

This archival image of the Earth's path around the Sun is an informative way to add colour to your walls. It measures 20x28 inches and is printed on fine Italian paper.

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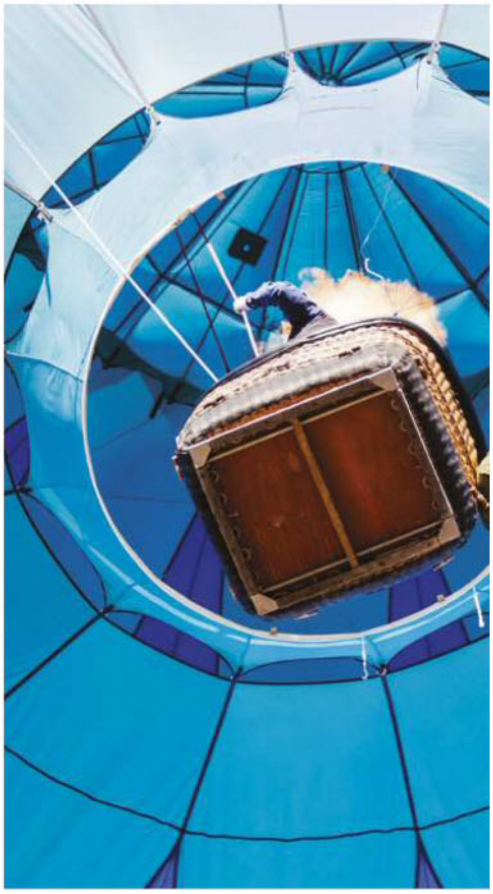

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WHAT I REALLY WANT TO KNOW IS…

Did life get started in a cosmic barbecue?

Ralf Kaiser is investigating how the first chemical bonds that led to DNA may have formed close to hot, carbon-rich stars

INTERVIEWED BY PAUL SUTHERLAND

One of the big mysteries in nature is how life originated. We know that DNA, that famous double helix, carries the code for life. I have been part of a team working to discover how the potential precursors to the building blocks of DNA – carbon ring structures embedded with nitrogen atoms – might have formed. These are the forerunners to key components of nucleobases, critical components of DNA. We want to find out how nitrogen atoms become incorporated into these bases.

Different theories suggest that these structures can be formed on Earth under very extreme conditions, which we felt were too specific to have distributed them widely. We looked to see how they might have been formed in space. So we tried to recreate cosmic conditions in the laboratory.

For many years, astronomers have used powerful telescopes to search for signatures of nitrogen-containing hydrocarbons called quinoline, focusing mostly on the space between stars – the interstellar medium.

I'm a physical chemist and I wanted to see if these precursors to life would form in hotspots like those found close to carbon-rich, dying stars – in a kind of cosmic barbecue. Our study focused only on the formation of nitrogen-bearing bicyclic molecules. It didn't apply to other bio-relevant molecules such as amino acids and polypeptides, for example. But it's one specific ingredient for life, if you like, and we were looking to see how it formed.

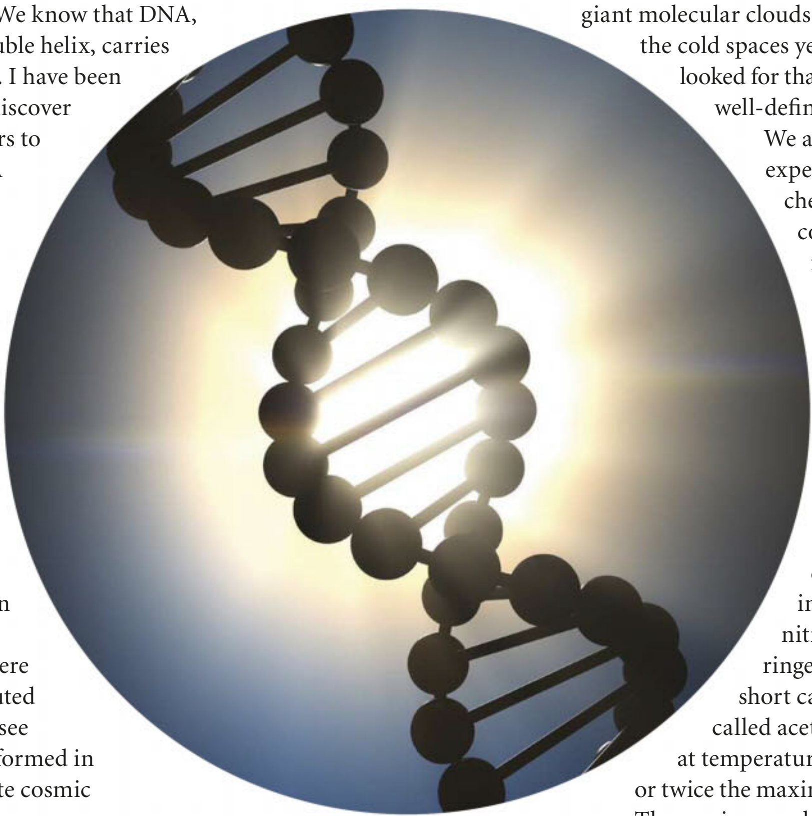
We were doing a laboratory experiment under very well-defined conditions where we knew the reacting conditions, the product, and the reaction pathway. And our major goal was to bring this research to the next level to help understand how precursors to life can be formed in space.

We decided to look at hotspots in space, but it could be that the molecules can also form in the condensed gas phase, in the icy regions found in giant molecular clouds. We haven't investigated the cold spaces yet. Rarely have scientists looked for that on a molecular level under well-defined laboratory conditions.

We also carried out simulation experiments to mimic the chemical and physical conditions that would be found near a star using a device called a 'hot nozzle', which had previously been used successfully to confirm soot formation during combustion. In our study the hot nozzle was used to simulate the temperatures close to carbon-rich stars. We injected a gas made of a nitrogen-containing single-ringed carbon molecule and two short carbon-hydrogen molecules called acetylene into the hot nozzle, at temperatures of around 700 Kelvin, or twice the maximum heat inside a domestic oven. Then, using synchrotron radiation (radiation created by charged particles in a magnetic field), we probed the hot gas to see which molecules formed. We found that the nozzle transformed the initial gas into one made of nitrogen-containing ring molecules quinoline and isoquinoline, which are considered the next step up in terms of complexity.

It was a very successful experiment for us in identifying a precursor molecule. It suggests these molecules can be synthesised in hot environments, then be carried by stellar winds to the interstellar medium where they condense as ices on cold nanoparticles (interstellar grains). For me it is pretty fascinating to be looking at what nature started a few billion years ago. When we can put all the parts of the puzzle together in a few years time, we might have a better answer to how complex nitrogen bases can be formed in space.

We are not even close to creating life in the lab, and we don't claim that will ever be possible. But our work may help tell us how life might have got started, and how the basic ingredients might have formed on a molecular level.



Nucleobases are a vital component of DNA, but how did the nitrogen get into those compounds in the first place?

ISTOCK

ABOUT RALF KAISER
Prof Ralf Kaiser ponders the meaning of life at the Department of Chemistry, University of Hawaii at Manoa, Honolulu.

The Southern Hemisphere in August

With Glenn Dawes

WHEN TO USE THIS CHART

1 AUG AT 00:00 UT
15 AUG AT 23:00 UT
31 AUG AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as stars crossing it set four minutes earlier each night. We've drawn the chart for latitude –35° south.

AUGUST HIGHLIGHTS

Mercury is heading towards its best evening appearance for 2015 in late August and September. As this inner world moves away from the Sun, it passes only 0.6° to the right of Jupiter on the 7th, low in the twilight. Mag. +1.4 Regulus (Alpha (α) Leonis) is just above this duo, with all three fitting in a 1.4° circle. Binoculars will help you to spot this group. Brilliant Venus is 7.6° to the left of this gathering. On the 16th the thin crescent Moon is 3.5° to the lower left of Mercury and 7° above on the 17th.

STARS AND CONSTELLATIONS

The Milky Way runs approximately north to south in the evening sky. Embedded within its glow, the Southern Cross and the Pointers have tilted over and commenced their southwesterly descent. In contrast, isolated mag. +0.5 Achernar (Alpha (α) Eridani) is rising in the southeast. Starting at Achernar, look towards the Pointer Hadar, mag. +0.6 Beta (β) Centauri. Skirt past the Small Magellanic Cloud to a region roughly halfway between these two beacons – this is the south celestial pole.

THE PLANETS

The western evening twilight sky has lots of planetary traffic, with Venus gone by mid-month and Jupiter following a week later. Mercury passes both as it rises out of the Sun's glare, setting after the end of twilight by month end. Saturn is the highlight, being well placed in the northwest evening sky for the entire month. Once this ringed world sets the morning sky belongs to the outer planets of Neptune and Uranus. Late August sees the return of Mars and Venus to the dawn sky.

DEEP-SKY OBJECTS

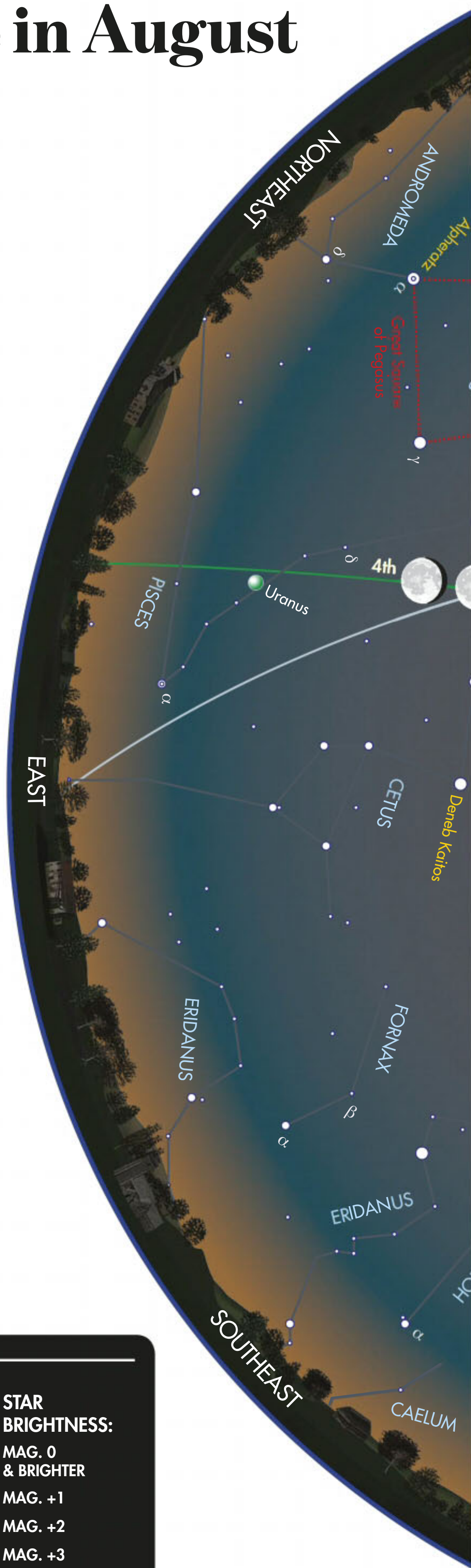
The hub of our Galaxy is rich in globulars, a great example being M4 (RA 16h 23.6m, dec. –26° 31m; pictured). Located 1.3° west of mag. +1.1 Antares (Alpha (a) Scorpii), this mag. +5.6 cluster has a bright central core surrounded by an impressive halo around 12 arcminutes across. It shows clumps of stars with numerous doubles and chains in a spectacular star field.

Look 3° north of M4 and you'll find the brilliant triple star Rho Ophiuchi (RA 16h 25.6m, dec. –23° 27m). The mag. +4.5 primary has mag. +7.3 and +6.8 companions, 2.5 arcminutes north and west respectively. A small telescope reveals the brightest star is also a great double comprised of mag. +5.1 and +5.7 components only 3 arcseconds apart.

CHART KEY

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER



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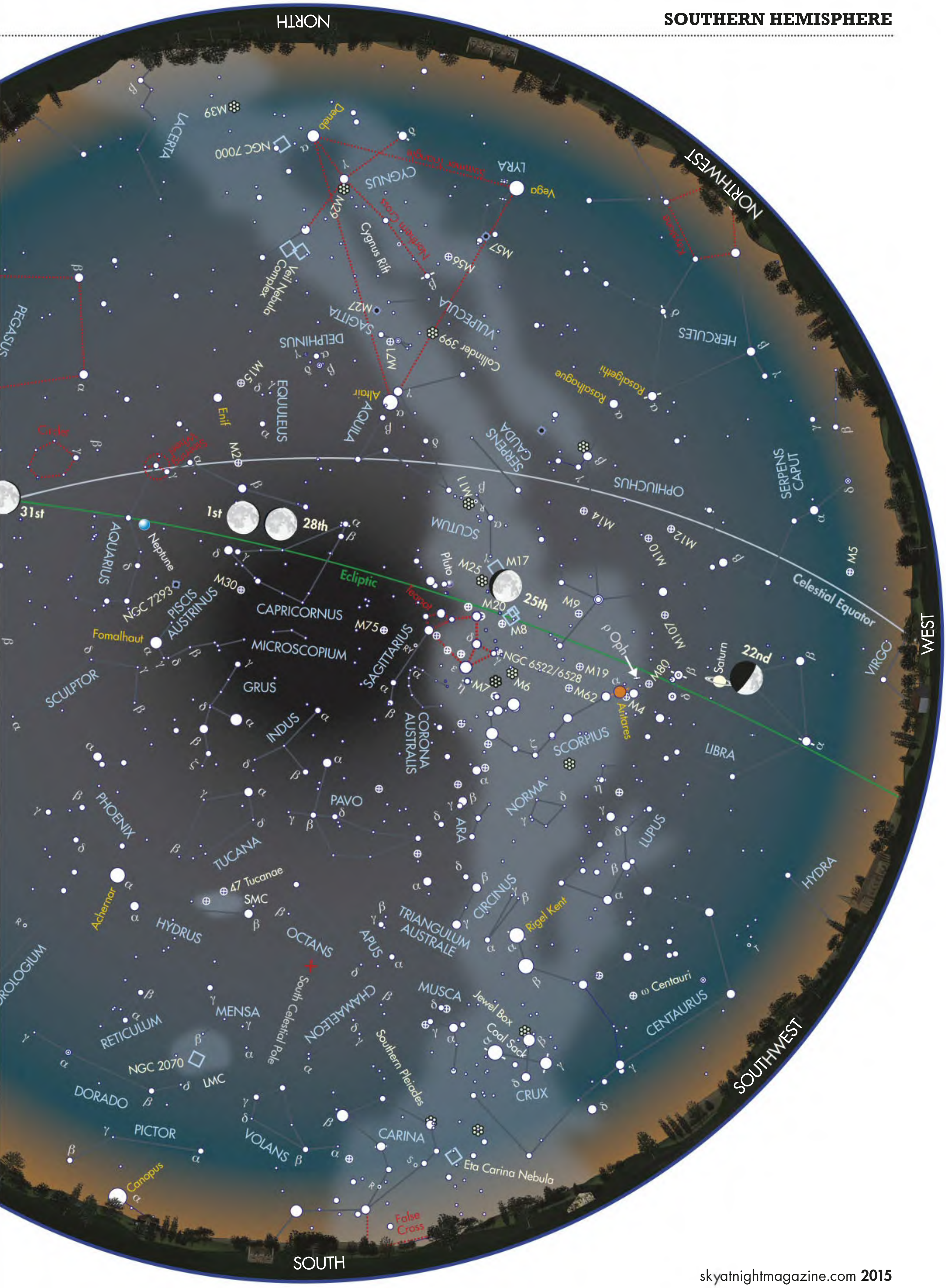
NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
Celestial Equator
Ecliptic
31st
1st
28th
25th
22nd
LACERTA
M39
Deneb
NGC 7000
CYGNUS
LYRA
Vega
M29
Northern Cross
Cygnus Rift
Veil Nebula Complex
M57
M56
HERCULES
PEGASUS
M27
SAGITTA
VULPECULA
DELPHINUS
Collinder 399
Rasalgethi
Rasalhague
M15
EQUULEUS
Altair
AQUILA
Enif
Circlet
M2
SERPENS CAUDA
OPHIUCHUS
SERPENS CAPUT
M11
SCUTUM
M14
M12
M10
M5
AQUARIUS
Neptune
Pluto
M25
M17
M30
NGC 7293
PISCIS AUSTRINUS
CAPRICORNUS
M20
M8
M9
M107
Fomalhaut
M75
SAGITTARIUS
MICROSCOPIUM
NGC 6522/6528
M19
M62
M80
M4
Antares
Saturn
VIRGO
SCULPTOR
GRUS
M7
M6
INDUS
CORONA AUSTRALIS
SCORPIUS
LIBRA
PHOENIX
PAVO
NORMA
ARA
LUPUS
TUCANA
47 Tucanae
SMC
Achernar
HYDRUS
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NGC 2070
LMC
Southern Pleiades
CRUX
DORADO
PICTOR
VOLANS
CARINA
Eta Carina Nebula
Canopus
False Cross

UK Retailer Guide

Find the right one for you: buy your telescope from a specialist retailer

It is quite easy to become daunted by the vast array of equipment that is available to today's amateur astronomers. Different makes, different models, different sizes and optical arrangements – if you're new to the hobby, how do you make sense of all these details and find the telescope that will show you the Universe?

The answer lies in buying from a specialist retailer – somewhere that really knows what they're talking about. Like the retailers in this guide, they'll have the practical knowledge that will guide you towards the scope that won't end up gathering dust in a cupboard.

Today there are over 1,000 models of telescope to choose from – refractors and reflectors, Dobsonians and Newtonians, Schmidt- and Maksutov-Cassegrains. And just as important as the telescope is the mount it sits on; but do you go for equatorial or altazimuth, manual or Go-To? And what about accessories like eyepieces and finderscopes?

That's certainly a lot to consider before making a decision, but a specialist retailer will help you make that decision, taking important considerations like portability, construction and price into account.

So if you need friendly, face-to-face advice and excellent aftersales service, free from biased opinions, specialist telescope retailers are the place to go for a helping hand through the technical literature and tables of figures. They'll help you find a scope that combines quality and convenience at a price that's right.

TELESCOPE HOUSE

Founded in 1785, Telescope House has been responsible for supplying many well-known Astronomers with telescopes and equipment. The late Sir Patrick Moore bought the majority of his telescopes from the company, including his very first instrument. With a friendly showroom in Surrey, a number one ranked retail website and a service centre with fully qualified staff, the company offers equipment from manufacturers such as Meade, Revelation, Coronado, Bresser, Skywatcher, Orion USA, TeleVue, Vixen and Explore Scientific. Whether it's advice on your first telescope, to setting up advanced Astrophotography systems, the staff at Telescope House have a wealth of experience and instant access to the right stock to back it up.

Telescope House

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TRING ASTRONOMY CENTRE

At Tring Astronomy Centre we know that choosing the right equipment can be a minefield, but we strongly believe that seeing telescopes in the flesh and talking to an expert in a relaxed environment can really help. That's why we have a coffee machine, a fully stocked bicuit barrel, and 45+ telescopes on display. As well as representing leading brands such as Celestron, Sky-Watcher, Baader Planetarium, Altair Astro, Vixen, Opticron, AstroTrac, iOptron, Lunt, Starlight Instruments, ZW Optical and many more we also offer a hire service so you can even try before you buy! So what are you waiting for? Visit or contact Tring Astronomy Centre and lets talk Astronomy!

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Established for over 60 years, we at Sherwoods are one of the Midlands leading suppliers of astronomical telescopes, binoculars and accessories. Through our website and showroom we are able to supply optics from some of the world's leading optical manufacturers including Celestron, Skywatcher and Meade at some of the lowest prices in the UK. We offer a full mail-order service including next day delivery on many items held in stock.

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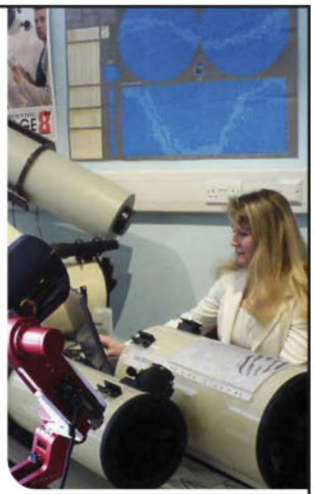
THE WIDESCREEN CENTRE



The Widescreen Centre is London's Astronomy Showroom, located in Sherlock Holmes territory off Baker Street in the heart of Marylebone - a family owned and run business since starting out in1971. Our experienced and highly knowledgeable staff will offer you quality, choice, expertise and service - see Celestron, Sky-Watcher, Meade, Orion, Tele Vue, APM, Takahashi and much, much more besides says Simon Bennett, Widescreen's MD and lifelong amateur astronomer, "If the correct equipment is purchased it will give a lifetime's enjoyment. This is our mission. We will never sell you anything you don't need" Watch out for Widescreen at Star Parties and exhibitions throughout the UK.

The Widescreen Centre

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www.widescreen-centre.co.uk
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Green Witch is one of the UK's leading suppliers of telescopes, binoculars and accessories for astronomy. Founded by former members of the Royal Greenwich Observatory in 1998, Green Witch is dedicated to helping you choose and use the equipment that is right for you.

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